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THE DYNAMIC MEASUREMENT AND UTILIZATION OF SOLAR HEAT.

THE apparatus invented by Sir John Herschel for studying the calorific intensity of the solar radiation on the earth's surface is generally known as an actinometer. The causes which modify the above-mentioned intensity are essentially variable, but the principal ones are the position of the earth in its orbit, the zenith distance of the sun on which depends the thickness of the atmospheric stratum through which the rays pass, and the state of the atmosphere. The temperature of surrounding objects, of which the radiation may be positive or negative with regard to the body exposed to the solar rays and the losses of heat due to air currents, are also elements of disturbance which practically render impossible the appreciation of the sun's influence by ordinary thermometric observations. It is hardly necessary to remark that the old plan of comparing two thermometers, one in the sun, the other in the shade, conduces only to erroneous conclusions.

Both Sir John Herschel and M. Pouillet conceived the idea of measuring the energy of the solar radiation by exposing to the sun's rays a given weight of water inclosed in an envelope having a certain determined surface. By noting the elevation of the temperature of the water at the end of a fixed time, and adding the losses due to the passage of the rays through the atmosphere and their dispersion, the above observers calculated approximately the total dynamic power developed by the sun.

Herschel's actinometer consisted in a small open receptacle, attached to a fixed standard. Pouillet's pyrheliometer, which figures in nearly all treatises on physics, was of polished silver. The vessel exposed to the solar rays contained 100 grammes of water, was 100 millimeters in diameter, and 15 millimeters in thickness. It was covered on the exterior with lampblack. This instrument could not, however, be used in winter when the temperature fell below 32° Fah.—a serious defect, as the heat of the sun's rays is most intense near the solstice, owing to the diminution of the distance between the sun and the earth, and the limpidity of the atmosphere during cold clear weather.

The loss of heat due to radiation in the pyrheliometer, the loss also owing to conductibility, augmented by air currents, the absence of proper means of causing the liquid to circulate in the heating receptacle, the rudimentary method of orienting the instrument by the hand, and finally the influence of the observer's own radiations, and the disturbance due to his respiration, were all causes of error. To eliminate all these defects, and to obtain exact measurement of the intensity of solar heat, has been Captain John Ericsson's object in devising the solar calorimeter, represented in Fig. 1. The instrument is fixed on a movable table within a rotary observatory. It consists of a copper receptacle, filled with water, and covered with lampblack on the exterior exposed to the sun. A thermometer placed in the liquid indicates variations of temperature, and an agitator, moved by a belt passing over a little pulley, keeps the water in motion and insures its equable temperature. The water vessel is placed in the bottom of a chamber, the flaring mouth of which receives a plano-convex lens whereby the rays are concentrated upon the calorimeter. In this chamber as nearly a perfect vacuum as is possible is maintained, and a water jacket is provided so that the interior temperature may be constant.

Fig. 2 represents an actinometer, also devised by Captain Ericsson, and intended to obtain the measure of the intensity of the solar radiation at a given moment. A hollow sphere of very thin copper is caused to rotate near the bottom of a cylindrical chamber, in which a vacuum exists as before. The sphere is blackened inside, and the sun's rays fall upon it through a thin plate of crystal which covers the upper part of the chamber. The latter is jacketed, and the water in the annular space is kept in constant circulation. The sphere is rotated by a hand-wheel attached to its arbor, which last passes through a stuffing box in the side of the chamber.

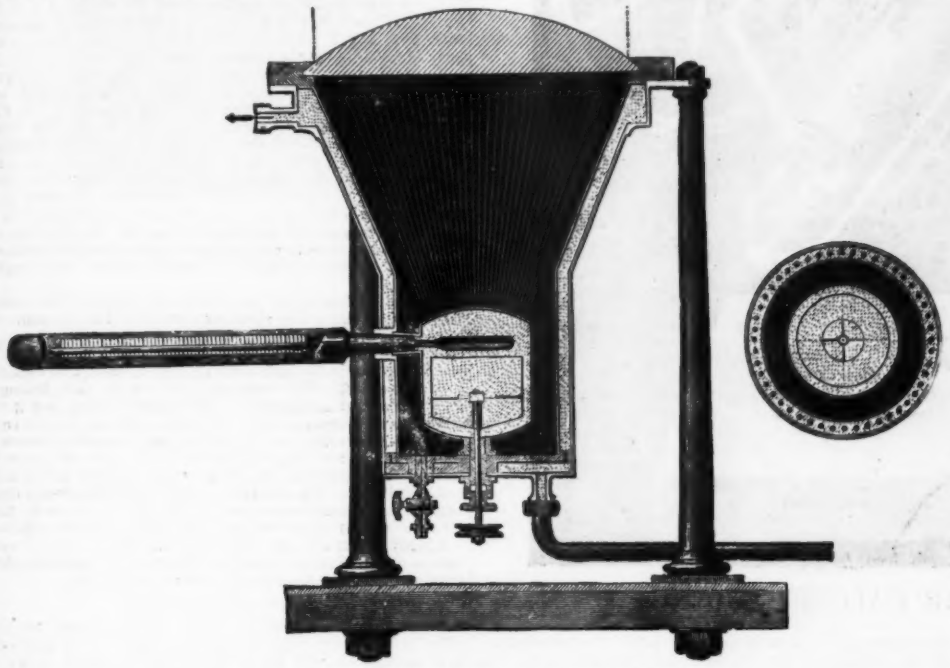


FIG. 1.—ERICSSON'S CALORIMETER.

The arbor is hollow, and a thermometer passes through; the bulb covered with lampblack being in the center of the copper sphere. The instrument, of course, rotates with the arbor.

It will be seen from the engraving that the capacity of the reservoir is considerable relatively to that of the graduated tube; and hence the smallest variations of temperature are clearly and rapidly indicated.

The instrument is supported by columns fixed to the table, which may be adjusted so that the axis of the chamber may point to the center of the solar disk. The water which circulates in the exterior envelope is kept at a constant temperature of 60° Fah. The point through which the thermometer passes is not tight, so that the air enters in the hollow sphere.

The mode of establishing comparison between this instrument and the ordinary thermometer is as follows: "The convex surface of the square being equal to four great circles, and the surface occupied by the luminous beam being equal to one great circle, it is evident that the cooling surface of the sphere is quadruple the surface of the solar radiation in the experimental case. If the cylindrical chamber radiates freely toward the center, the temperature conserved by the sphere exposed to the cold radiation from all points will be only one-fourth of that which may be communicated by the solar beam. The chamber is kept at 60° Fah., and the heat radiated by it toward the centre cannot exceed that limit. It may be demonstrated that the elevation of the temperature of the sphere represents only one-fourth of the calorific intensity of the rays which traverse the crystal plate. The temperature of the air inside the sphere is the same as that of the metal, and hence the thermometer within will show the degree with sufficient nearness. The indications of the thermometer then multiplied by 4 will give the true intensity of the solar rays at the surface of the earth, less the quantity of heat absorbed during passage through the crystal plate. The results of careful observations combine to show the exactness of this conclusion.

In Fig. 3, on next page, is represented Capt. Ericsson's new engine for the utilization of solar heat in the production of motive power. It is calculated that the heat radiated by the sun during nine hours per day, for all the latitudes comprised between the equator and the 45th parallel, corresponds per minute and per square foot of normal surface to the direction of the rays to 3·5 thermo units of 772 foot pounds. Hence, a surface of 100 square feet would give a power of 270,000 foot pounds, or from 8 to 9 horse-power. The engine illustrated is on the caloric system, and has run at 420 revolutions per minute with the sun near the zenith and during fine weather.

DETERMINATION OF STRESS—BOWSTRING GIRDER.

By Lieut. GEORGE S. CLARKE, R.E.

THE following method for obtaining the stresses in the various bars of a bowstring girder involves no principles which are not already familiar to those who are accustomed to make use of graphic processes. I venture to think, however, that it is a somewhat novel application of known principles, and that its extreme simplicity will recommend it to those who are acquainted only with the more laborious methods of calculation. A simple graphic process is often valuable as a check on calculation, even if it be deemed insufficiently accurate to serve as the sole basis of operations.

The girder has a span of 192 feet, divided into 16 bays of 12 feet. The dead load has been taken at 0·65 tons, and the traveling load at 1·0 tons per foot run. The vertical bars are supposed to act both as struts and ties, the crossed diagonals as ties only. Assuming that the dead load is distributed, half at the upper and half at the lower joints, there will be—dead load on upper joints, at 3·9 tons; total load on upper joints, 3·9 tons; total load on lower joints, 15·9 tons; total load on end joints, 9·9 tons.

(1) *Booms.*—The maxima stresses in the booms will occur when the girder is fully loaded. To determine these stresses, therefore, it will be merely necessary to draw an ordinary stress diagram for a load of 3·9 tons on each upper joint, 15·9 tons on each lower joint, and 9·9 tons on each end joint. In drawing this diagram, it will be necessary to deal with that

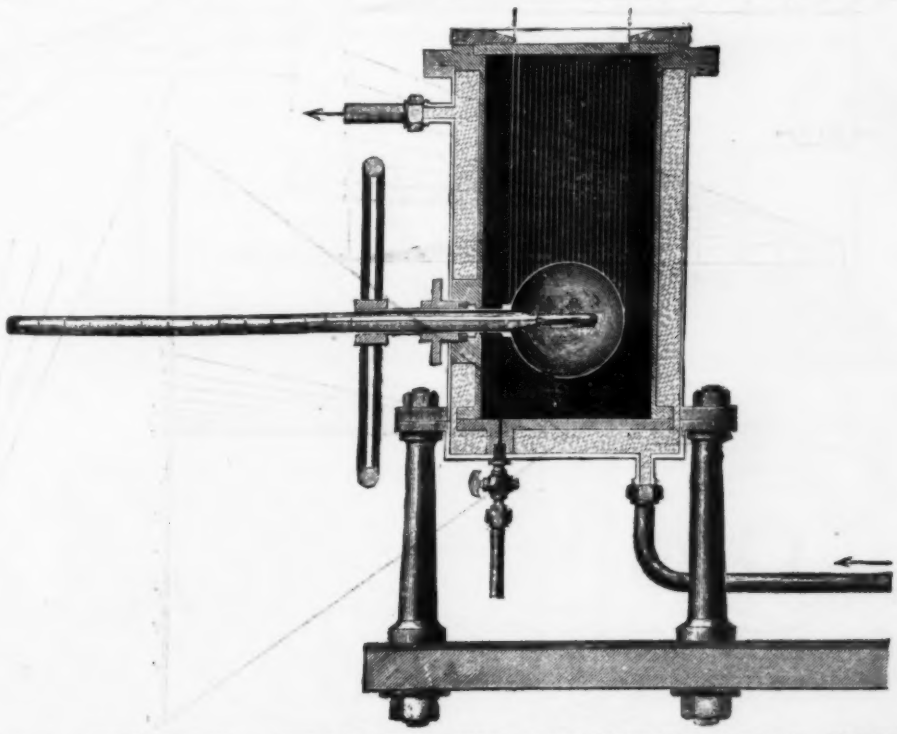


FIG. 2.—ERICSSON'S APPARATUS FOR MEASURING SOLAR HEAT.

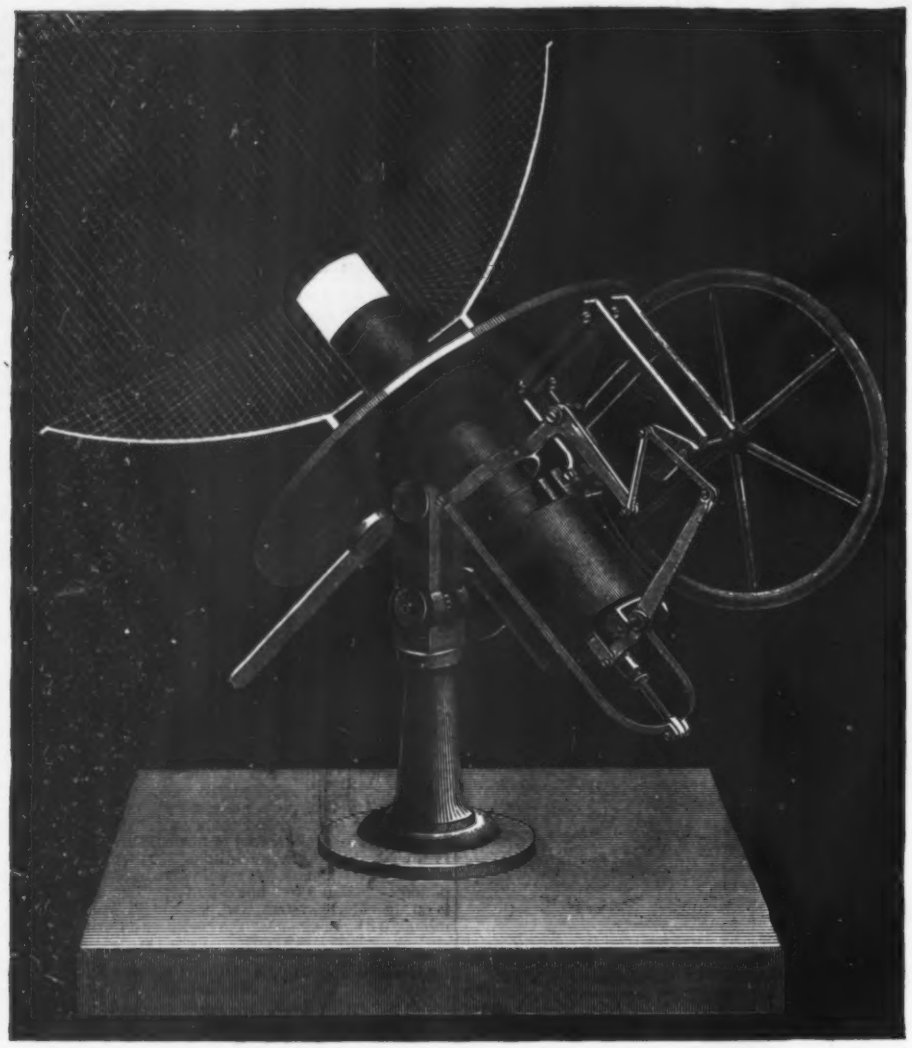


FIG. 3.—ERICSSON'S SOLAR CALORIC ENGINE.

system of triangulation only in which the diagonals are in tension.

(2) *Diagonals and Verticals.—Dead Load.*—It will next be required to draw a second stress diagram for dead load only. The loads in this case will be 3·9 tons on each upper and lower joint and 1·85 tons on each end joint. As before, diagonals in compression must be left out of consideration. The stresses in the diagonal and vertical bars, given by this diagram, must now be tabulated. Tensile and compressive stresses have opposite signs.

The construction of these two diagrams presents no special feature.

Maxima Stresses in Diagonals.—Traveling Load.—Suppose the traveling load to come on the girder at B and move to A, Fig. 1, the maximum tension in any diagonal *e f* will arise when the traveling load moving from B arrives at s_3, the center of the bay under *e f*. Similarly, the greatest tension in the diagonal next on the left of *e f*, will arise when the train arrives at s_4, and so on. Suppose the diagonal *e f* cut by a section plane $\alpha\ \beta$, which also cuts the two booms. Then, to obtain the maximum stress in *e f*, it will be necessary to determine the maximum shearing force at s_3, to suppose this shearing force to act as a reaction at A, and to resolve it along the direction of the three bars cut by the plane $\alpha\ \beta$.

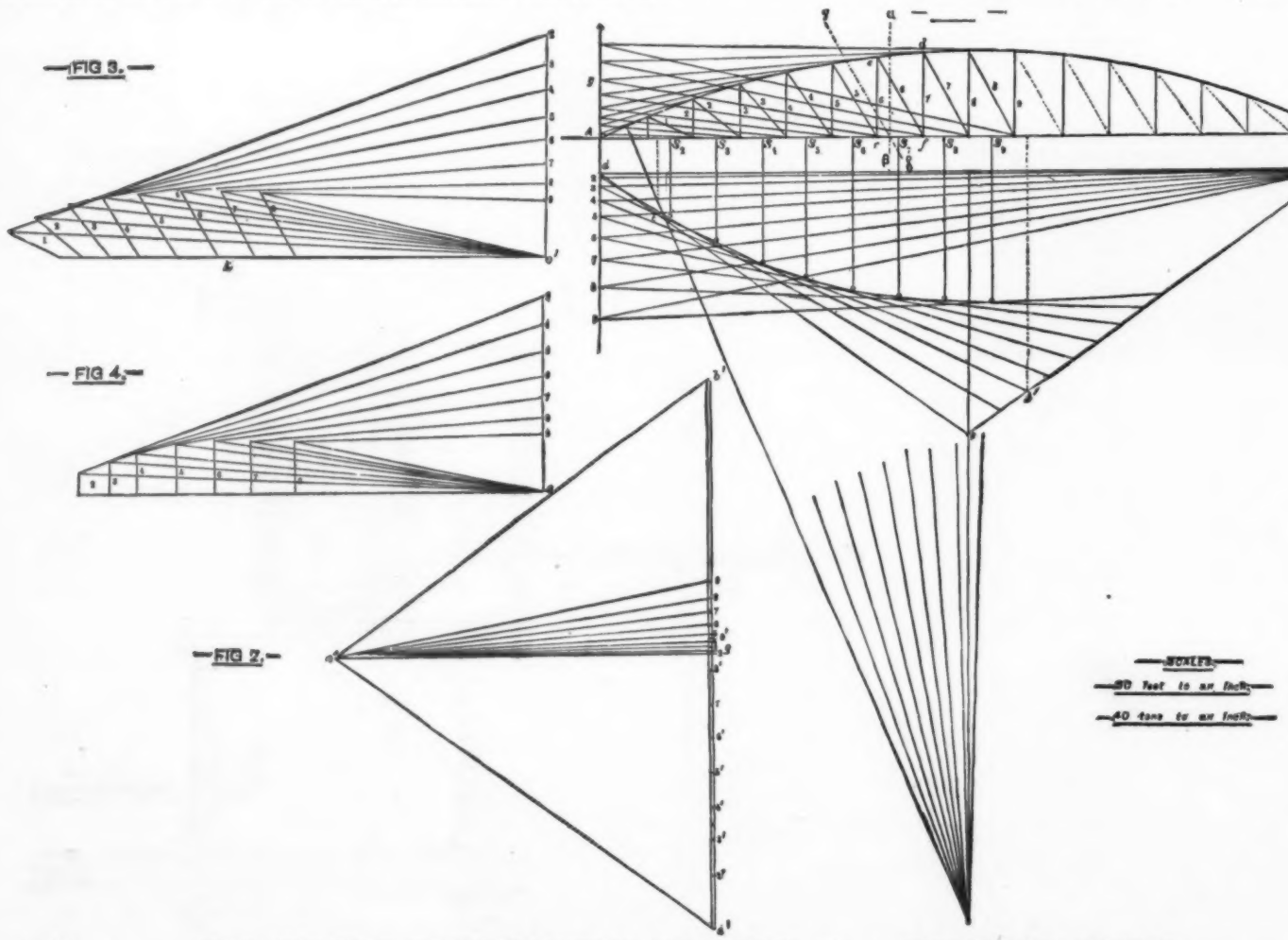
The shearing forces at s_2, s_3, s_4, etc., are obtained as follows: Make *b' a'*, Fig. 2, equal to the total traveling load, bisect *b' a'* by a perpendicular O' *o*, which can be made any convenient length. Join O *b'* O *a'*. In Fig. 1, draw *a c* parallel to O *a'* and *b c* parallel to *b'* O (Fig. 2), *a* and *b*, Fig. 1, any points vertically equidistant from A and B. To obtain a tangent to the funicular curve at a point vertically below s_2, bisect As_2, Bs_2, by verticals, cutting *a c* and *b c* in *t* and *t'* respectively, then *t t'* is the required tangent. Tangents at points vertically below s_2, s_3, s_4, etc., are similarly obtained. These tangents will of course cut *c b* and *c a* at equidistant intervals. To obtain the shearing force at s_2, produce *t' t* to cut the vertical A *a* produced, in 3. Join 3 *b*. In Fig. 2, draw O$_3$ parallel to 3 *b*, Fig. 1, and set off along *a' b'* from *a'*, a distance *a'* 3' equal to the load covering the length A s_2 of the girder. Then 3 3', Fig. 2, represents the maximum shearing force at s_2, Fig. 1. The distances 2 2', 4 4', etc., Fig. 2, similarly obtained, give the shearing forces at s_3, s_4, etc., Fig. 1.

To obtain the maximum stress in the diagonal *e f*, suppose the shearing force 7 7', Fig. 2, to act as a reaction at A, and resolve it along the three bars cut by the plane $\alpha\ \beta$. In Fig. 3 make the vertical O' 7 equal to 7 7', Fig. 2. In Fig. 1 produce the segment *d e* of the upper boom to cut the vertical *a* A produced in *g*, join *g* to *f*, the intersection of the other two bars cut by the plane $\alpha\ \beta$. In Fig. 3 draw lines from O' parallel to *d g* and *f g*, Fig. 1; these lines intersect in *i*; draw *i k* parallel to *e f*, cutting a horizontal through O' in *k*; then *i k* represents the maximum stress in the diagonal *e f*. The stresses in the remaining diagonals are similarly obtained. The construction in Fig. 3 is carried as far as the eighth diagonal.

The determination of the stresses in the verticals is similarly carried out. The shearing force 7 7' (Fig. 2), supposed to act as a reaction at A, is resolved along the three bars cut by the plane $\gamma\ \delta$, Fig. 1. The construction is shown in Fig. 4. The stress in the end vertical, Fig. 1, cannot be obtained by this method. This vertical does not, in fact, belong to the system of triangulation under consideration, and it will be sufficient to make it able to sustain, either a weight equal to the load covering one bay, or the heaviest axle pressure, if the latter is greater than the former. The process above described can be carried out, if necessary, for the dotted diagonals of Fig. 1. The diagonals inclined in the reverse direction will be strained when the train moves from A to B; their tensions will, of course, be the same as those above obtained.

Finally, the maximum stresses in the diagonals and verticals as above obtained must be tabulated and added to those obtained from the dead load diagram.—*Engineer.*

SPONTANEOUS COMBUSTION OF SILK.—Some weighed silks, which were insured, having while stored developed heat enough to ruin the goods, though no flame appeared, the insurance company refused to pay the insurance. The court decided that the silk was burned, and ordered payment.—*Reimann's Färberzeitung.*



THE GRAPHIC DETERMINATION OF STRESS IN A BOWSTRING GIRDER.

CEMENT FOR WOODEN BATHS.

IN the *Monatsblätter* the following cement for wooden baths is given: Melt thirty grammes of colophonium and thirty grammes of yellow wax in an iron crucible (a saucepan will do,, and to that add thirty grammes of finely powdered calcined ocher, and keep the whole mass fluid for some time by stirring. Now pour some into the joints that are not watertight, and when it has cooled it will be as hard as stone.

THE BOURDON PRESSURE GAUGE.

MECHANICAL engineers are frequently called upon to explain the action of this class of indicators, and yet there are but few who seem to have anything like a clear idea of the theory. Mr. Van Buren furnished us with an article upon this some years ago; yet, while the general principles enunciated were true, there were flaws in the reasoning and geometrical demonstration which rendered its adoption un satisfactory; and it is to the correction of these errors that the present notes are directed and submitted to those who may be interested in obtaining a clearer statement.

In the article referred to, we are told that the tube of this gauge will, when under internal pressure by some elastic medium, as steam, tend to assume that form which will

contain the greatest volume with the given surface. The form of the tube is a curved one, of elliptical cross section, the minor axis of which lies in the plane of the curve, Fig. 1.

If we suppose the pressure to be sufficient to cause the complete change of form, it will be readily seen that the new form of the cross section will be a circle, as that is the only figure which will satisfy the conditions; the circumference of the circle being of course equal to the periphery of the ellipse. This is shown by dotted lines in Fig. 1. We are further informed that in assuming this new form the tube becomes less curved, and the indications are made by the operation of suitable machinery by this tendency to straighten.

It is in the proving of this tendency to straighten that the special difficulty lies, and, although the fact of the action is admitted, it is still desirable to clearly demonstrate it. To do this we will follow Mr. Van Buren further: "Let Fig. 2 represent a section of the tube formed by a plane passing through the minor axes of the elliptical cross section; *a b* and *c d* will represent the minor axes of two consecutive cross sections, also represented in Fig. 3 by *a b*. After the change of form, it is obvious that these minor axes must extend. If the sections were perfectly free and independent of each other, this extension would take place radially as *a' b'*, *c' d'*, Fig 2, and shown by *a' b'*, Fig. 3. They are, however, bound together by the material (metal surface) which resists this action, and *a b*, *c d* will take intermediate paths arriving at *a'' b''*, *c'' d''*, so that the arcs *a c* equals the arc *a c*, and *b'' d''* equals *b d*. Joining *a'' b''* and *c'' d''*, we see that these lines are less inclined toward each other than *a b* and *c d*. *Hence the tube has straightened.*" The most obvious error here is a geometrical one; for how is it possible for the tube to be less curved in the new form when the curves of both are concentric and the center curve identical? The

origin of this flaw lies in another one, the incorrect length of *a'' b''* and *c'' d''*, Fig. 2. The correct length of these lines is found in Fig. 3, which represents any regular cross section, and *a'' b''*, *c'' d''* in Fig. 2 must be equal to *a' b'*, Fig. 3. It is clear that this correct length is shown. Fig. 2 by *a' b'*, *c' d'*, and also it is obvious that no line oblique to these radials and intercepted by the two concentric arcs can be equal to the radials thus intercepted, as the shortest distance between the arcs is measured on radials. Hence *a'' b''*, *c'' d''* in this figure are too long, and we do not find the theorem demonstrated.

To show, however, that the tube does conform to the theory, we have to find such center as will bring *a' b'*, *c' d'* (Fig. 2), parts of radii intercepted between the two concentric arcs, and yet have the arcs included between these lines equal to those included between *a b*, *c d*, each to each. Let the section be again represented by Fig. 4. It will only be necessary to show that the curve through the center must be of longer radius, to prove the tube will straighten. Take a middle section *f*, and, considering the tube free, it may be assumed that after change of form the extended axes *e'' f''* will remain in the same plane of cross section as shown; for there is no reason why it should incline one way more than another. The new curves will pass through *e''* and *f''*, and the centre curve will pass through *o*, the centre of *e'' f''*, which has not altered its position during the extension. If the center from which the curves are struck remains unchanged as *x*, we have a figure similar to Fig. 2, and in which, when we satisfy the conditions regarding the length of *a'' b''*, etc., as just enunciated, we have *included arcs* of evidently improper lengths. Again, if the center is nearer to the center of *e'' f''* as *x'*, we aggravate the above error as shown by dotted lines in Fig. 4. Therefore, we conclude that the center *z* must be further from *o* than is *x*, and, if so, it is plain that the center curve will be struck with a longer radius than *o x*, the original length; and hence this curve is nearer to a straight line, which indicates that the tube, after change of form, is necessarily less curved than before. The algebraic proof of this is very simple after what has been shown, as we have the included arcs in both cases, and the intercepted parts of radii in both cases, from Fig. 3, assuming numerical lengths in Figs. 2 and 3 *before change of form.*

By a little careful study another conviction will be reached about which there is frequent discussion among those who have given the subject but little thought. This is, that a curved tube of circular cross section, closed at the end, under internal pressure, will not tend to straighten, as its form is already of greatest capacity with the given surface; but where the pressing medium flows rapidly through the tube, as an open hose, the inertia of the fluid tends to resist any curvature of course, and brings in other considerations. The tubes we have considered are understood to be of such material that the quality of stretching may be left out without detriment to the theory or demonstration. A. B. W.

COMBINED ENGINE AND CLAY MILL.

THE illustration shows a combined engine boiler and clay mill recently constructed by Mr. F. W. Jackson, of the Kingsbury Iron Works, Dalston, Eng., for the Littledean Woodside Colliery, Cinderford, and is specially adapted for grinding and pugging fire and other clays, bricks, flints, etc. The mill is provided with two curved brackets of tee-section, replacing the usual crosshead, side frames, and strut. These curved brackets are connected in the center, and provided with a bush in which the upright shaft of the mill works. The joint is secured by four ¾ in. bolts with nuts and lock nuts. The pan, which has an unusual amount of dish on the sides and center, is stiffened round its upper edge with a heavy ring. The object of giving an increased dish to the pan is to reduce the tendency of the mill to throw out the material when being driven at a high speed. On the bottom of the pan is bolted a strong bevel wheel by six countersunk headed bolts. The wheel has six arms and a deep boss, through which the upright shaft passes. The latter is provided with a cap or ring at its lower end on which the pan and crown wheel rest, the part that extends through the wheel and ring being turned and faced, and secured to the wheel by a key. A hole 3 in. in diameter by 6 in. long is formed in the bottom of the shaft to receive a hardened steel pin prevented from turning by a tee-headed bolt screwed into it, and fitting in a slut cut in the upright shaft This pin works into an adjustable bearing consisting of two cylindrical cups. The inner, which is bored larger than the pin, has a hardened steel disk placed at the bottom and held by a pin. This cup drops inside a second, which has a square base and holes for the holding-down bolts, and through the center of which a wrought iron wedge passes, by means of which the necessary adjustment is obtained. The underside of the inner cup is slotted to receive the wedge. The crushing gear consists of two rollers, each 3 ft. 6 in. in diameter, 15 in. wide on face, and weighing 30 cwt. each. These rollers do not run in the same track, but one works on the inner and the other on the outer edge of pan, wearing evenly the heavy false bottom which is fitted in the pan. A strongly ribbed cast iron crosshead is provided with socket-ends, into which the wrought iron cross-arms fit, that form the axes of the rollers. These latter are kept in their respective positions by means of coliars, which on the bracket side are made with oblong ends to work in the slots of the brackets, and allow the rollers to rise and fall, any tendency of the cross-arms to twist round being prevented by means of set screws in the end collars. These machines can be filled and discharged mechanically if desired. Where manual power is employed, a large wrought iron shovel mounted on a column with a jointed lever is employed. Wrought iron adjustable scrapers are supplied fixed on wrought iron bars for cleansing the rollers and pan, as shown in the drawing. The mill is driven direct through a bevel gear and clutch by a 10 horse power engine. The engine has a 10 in. cylinder, 14 in. stroke, and is bolted to the boiler as shown. The boiler is 10 ft. high, 4 ft. in diameter, and is provided with 24 tubes 2¼ in. in diameter.—*Engineering.*

Fig. 1.

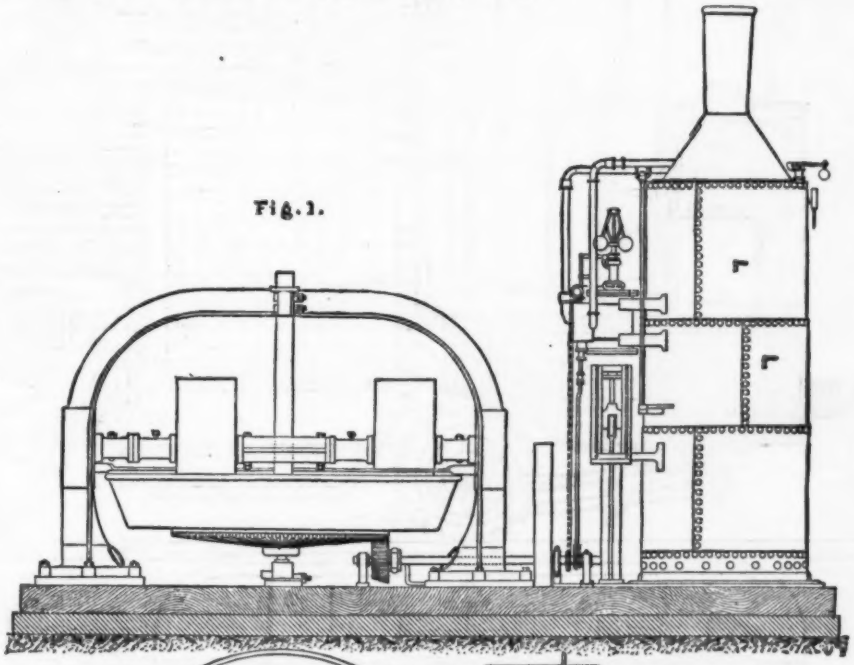
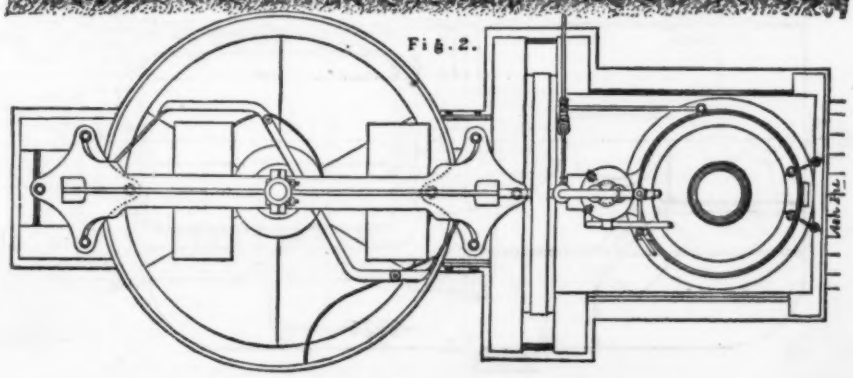


Fig. 2.



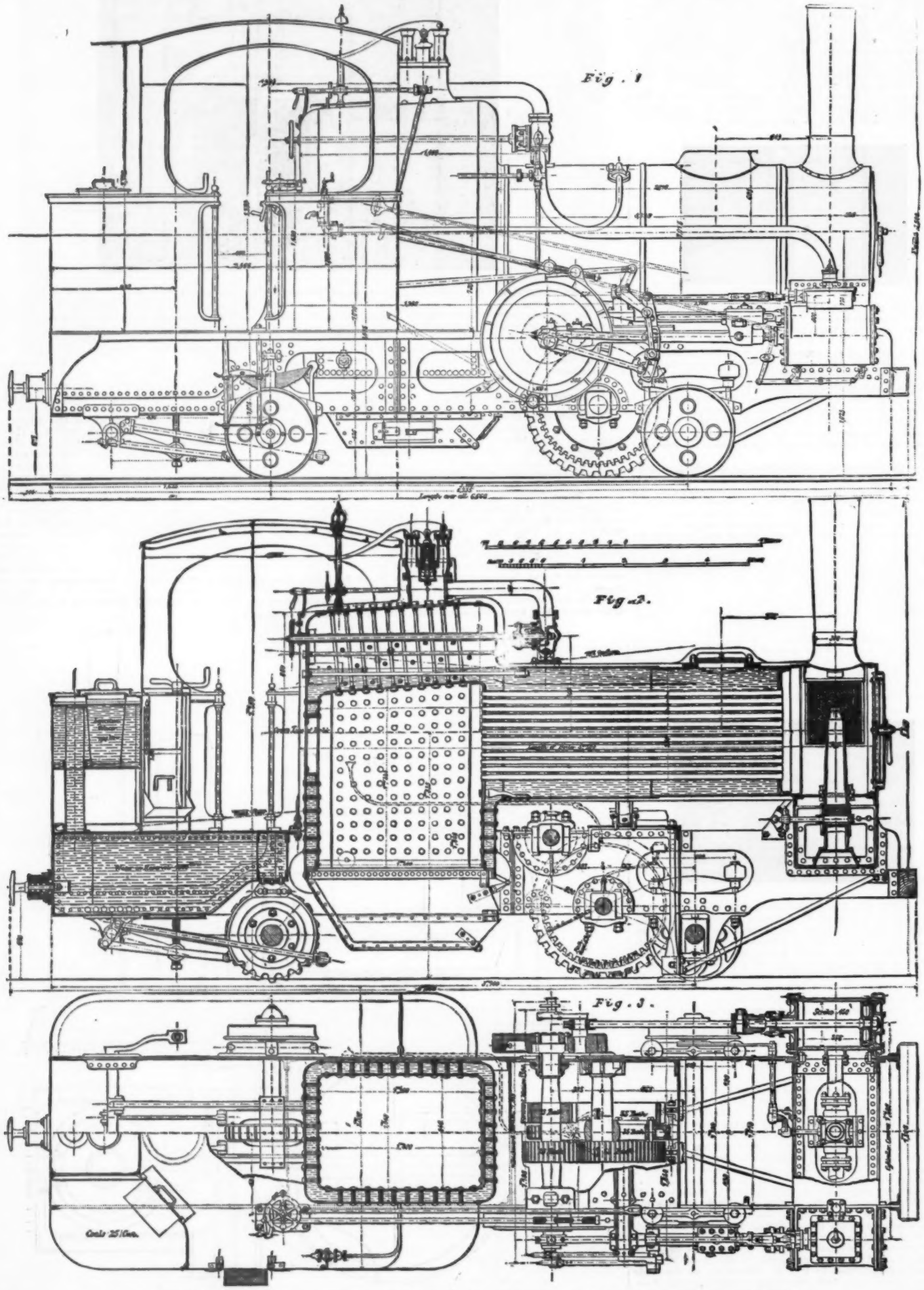
COMBINED ENGINE AND CLAY MILL.

RACK RAILWAY LOCOMOTIVE.

THE Kahlenberg, near Vienna, is a mountain which rises abruptly from the banks of the Danube, and which, on account of the splendid views to be seen from the summit, is a great resort of holiday seekers. A rope railway was opened in 1873, and it ascends the mountain on the northwestern side, it being, in fact, situated on the flank of the Leopoldsberg and not of the Kaldenberg proper. At the same time that this rope railway was projected another company was also started for constructing a second line ascending the Kahlenberg on the eastern side, this second railway being considerably longer and having much flatter gradients than its rival, while, instead of being worked by a rope, it is provided with a central rack on the plan introduced on the Mount Washington Railway and subsequently adopted with so much success on the Rigi. It is a locomotive for this second line which forms the subject of our present engravings.

The line, which has a gauge of 4 ft. 8½ in., commences at Nussdorf, the first station from Vienna on the Franz-Josef Railway, and it passes through Grinzing and Krapfenwald to the summit of the Kahlenberg, its gradients being successively 1 in 25, 1 in 12½, 1 in 20, 1 in 10, 1 in 33, 1 in 10, and 1 in 33. The line, it will be seen, is very much less steep than the Rigi Railway. The line is laid with rails weighing 20 kils. per metre, or about 40 lbs. per yard, while between the rails, and securely fixed to the sleepers, is the rack, composed of two 2·4 in. by 4 in channel irons with wrought iron teeth between them, these teeth being of 4 in. pitch. The rack is constructed very similarly to that of the Rigi Railway already described in our pages, and it weighs 55 kils. per metre, or about 110 lbs. per yard.

The locomotives for working the lines are built by the Schweizerische Locomotiv und Maschinen-Fabrik of Winterthur, of which works Mr. Charles Brown is the manager, and their general design will be readily understood from our en-



LOCOMOTIVE FOR THE KAHLENBERG RACK RAILWAY, NEAR VIENNA.

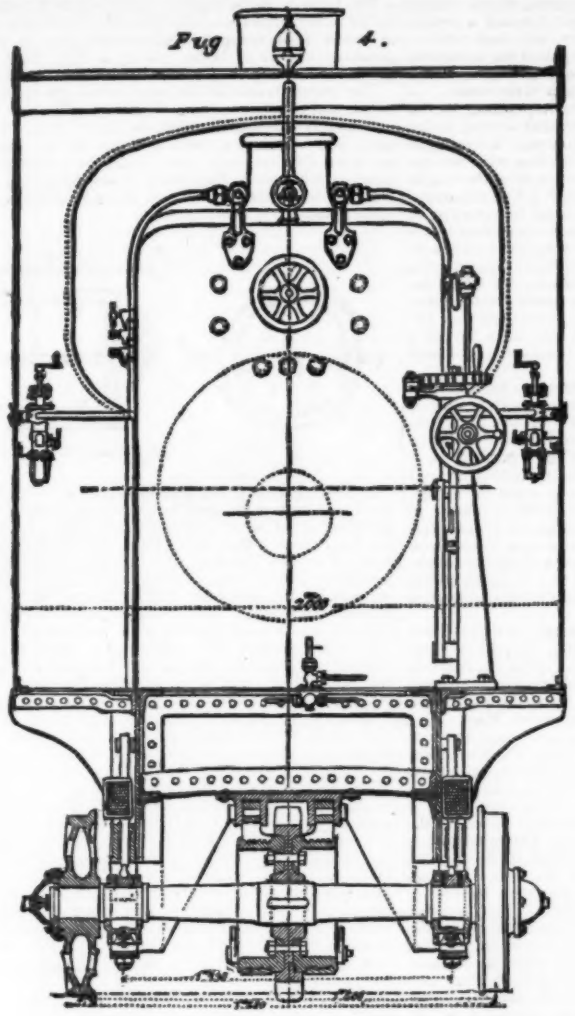


Fig. 4.

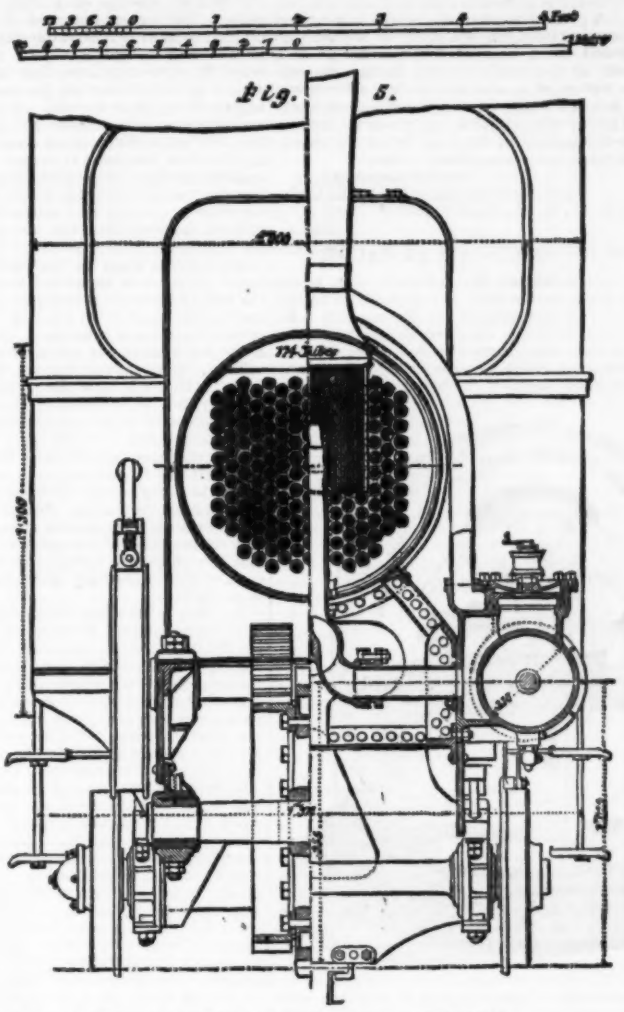


Fig. 5.

LOCOMOTIVE FOR THE KAHLENBERG RACK RAILWAY, NEAR VIENNA.

gravings. The engine, we may remark, goes up the line at the tail of its train, the carriages being pushed before it, while in going up the hind end goes first, the chimney end being always lowest. A dotted line in Fig. 2 shows the level of the water when the engine is going up an incline of 1 in 10.

The boiler is of the ordinary locomotive type, but it has an exceptionally high firebox casing, the top of this casing and the crown of the firebox sloping downward towards the hind end, as shown. The barrel is so placed with regard to the firebox that it is full of water when the latter is at the proper level. A diaphragm plate is fixed across the barrel above the tubes, as shown in Figs. 2 and 5, so as to divide the ascending and descending currents. The firebox is 3 ft. 11¼ in. long, 2 ft. 9 in. wide, and 4 ft. 4¼ in. high at the center, the heating surface it exposes being 65·3 square feet. The barrel contains 174 tubes, 1·417 in. inside and 1·575 in. outside diameter, and 7 ft. ¼ in. long, the heating surface exposed by them being 506·6 square feet, making the total heating surface 571·9 square feet. The grate area is 10·6 square feet. The arrangement of the boiler stays and of the steam pipes and regulator will be understood from the engraving.

The cylinders are 13 in. in diameter, while the pistons have a stroke of 17·72 in., and are fixed outside, as shown, the connecting rods, taking hold of pins on cranks disks at the ends of a strong shaft which extends across the engine in front of the firebox. One of the crank disks—that on the right hand side—is fitted with a powerful brake, as shown in Figs. 1 and 3. On the crank shaft are keyed two pinions with 23 teeth of 2 in. pitch, which gear into wheels with 55 teeth on a second motion shaft, as shown in Fig. 3. Between the two wheels just mentioned is securely bolted the wheel gearing into the rack, this wheel having 35 teeth of 4 in. pitch, and the diameter on the pitch line being 41·36 in. Owing to the proportions of the gearing the crank shaft makes 2·391 revolutions for each revolution of the rack wheel, and the tractive power exerted by the engine for each pound of effective pressure on the piston is thus:

$$\frac{13^2 \times 17{\cdot}72 \times 2{\cdot}391}{41{\cdot}36} = 173 \text{ lbs.}$$

As the boiler is worked at 9 atmospheres, or 132 lbs. per square inch, a tractive=or under the circumstances rather a pushing—force of fully 18,000 lbs. can be exerted when required.

The general arrangement of the working gear is shown clearly in Figs. 1 and 3, and will require no special explanation; we may remark, however, that when descending with a train the engine is run in back gear and a kind of cock or valve with which the exhaust pipe is fitted is then turned so that the cylinders take in pure air and not dust and ashes from the smoke box. The arrangement of this valve and the gear for working it are shown in Figs. 2, 3, and 5. The air compressed by the action of the pistons when the engine is thus running reversed is not discharged into the boiler (the regulator being closed), but is allowed to escape through the air cock, the opening of which is adjustable by the driver.

The engine is carried on two pair of wheels, the center of axles being 10 ft. 2 in. apart. The leading wheels are fixed on their axle in the usual way, and the weight is transmitted to their axle boxes through india rubber springs. The trailing wheels, on the other hand, run free on their axle, the latter carrying a strong spur wheel gearing into the rack and also a pair of grooved drums fitted with a powerful brake. This arrangement is best shown in Figs. 2 and 4. It will be seen from the above description that three modes of checking the engine and train are provided, namely, the brakes on the trailing axle and crankshaft and the running of the engine in reverse gear. By these means a most perfect control of the engine and train is maintained during the descending journey.

The engine is strongly framed, and a water tank containing 220 gallons of water is provided between the frames at the hind end, while a small supplementary tank above contains 19·8 gallons more. The coal box is at the back of the footplate, and contains 25 cwt. The weight of the engine empty is 15·76 tons, or in full working order 19·44 tons, while the load taken up consists of three carriages weighing 32½ tons empty; or about 42 tons when full of passengers. Altogether the locomotive is a great improvement on those with vertical boilers used on the Rigi Railway, and, as in all engines constructed under Mr. Brown's directions, the details are well worked out.—*Engineering.*

THE NEW BRIDGE AT PITTSBURGH.

PITTSBURGH is eminently a city of bridges—necessarily so on account of the three large rivers flowing through her limits. While some of them are of humble pretensions, others will compare favorably with bridges to be found anywhere. The last one erected belongs to the latter class, and is so near a state of entire completion as to have justified a formal opening on March 31.

The structure is a stiffened chain suspension bridge, was built by the American Bridge Company, of Chicago, and designed by the company's engineer, Mr. Edward Hemberle. It is unlike any other similar structure in the world, and may be briefly described as follows:

The bridge consists of three spans. The center span is 800 feet and the end spans 145 feet each—the total length from back to back of the anchorage being 1,345 feet. The roadway rises from each end, and at the center of the channel is 83 feet above low water. The saddles on top of the towers, upon which the chains rest, are 180 feet above low water, and the deflection of the chain is 83 feet. The floor is divided by iron hand-rails into a 21-foot wagon way, and two 6½-foot sidewalks. The piers are built of Baden sandstone, laid in cement. The towers consist of four columns 30 inches square, braced together by lattice work, and are of wrought iron, except the bases of the columns. The saddles on top of the towers are of wrought iron, and are on steel rollers, to allow for changes caused by variations of temperature, etc. There are two chains, one on each side of the bridge. The links are formed of from eleven to fourteen bars, 20 feet long and 8 inches by 2 inches to 8 inches by 1 inch in size, and are connected by 6-inch pin bolts, the same bolts also connecting the links. The bridge is stiffened by means of rigid chords, which extend (above the chains) at an undeviating angle, from the towers to the center of the middle span, where they are connected by a hinge, to allow for expansion and contraction.

The material used: Timber in foundations, 4,442 feet, board measure; masonry in anchor walls, 10,868 cubic yards; masonry in piers, 7,507 cubic yards; iron in foundations, 12 tons; wrought iron in superstructure, 2,084 tons; cast iron in superstructure, 52 tons; steel in superstructure, 32 tons; timber in superstructure, 810,000 feet, board measure; number of links in the chains, 1,832.

The cost of the bridge was $525,000, and although it was erected by a Chicago company, nearly all the ironwork was done by Graff, Bennet & Co., of this city.

The total weight upon the main span at one time on Saturday was 457½ tons.—*American Manufacturer.*

THE ICE BOAT WHIFF.

To the Editor of the Scientific American Supplement:

DEAR SIR: In SUPPLEMENT No. 67, I notice, in an article under the heading of "Ice Boats on Land," the remark made by a correspondent from South Bay, N. B., that he had just finished reading your description of the Ice Yacht Whiff, and that he judges it "a very weak boat."

I hesitate, on account of the value of your space, to ask you to kindly publish these lines; but I feel it incumbent upon me to make some reply, not as owner of the Whiff, but out of regard for those numerous lovers of ice-yachting who may have been induced to improve their present vessels or to entirely rebuild from the model of the Whiff, as seen by them at the Centennial, or from the working drawings of said yacht published in SUPPLEMENT No. 63.

As such persons may be somewhat influenced by the conjectures of your correspondent, I beg to say, for their reassurance, that in an experience of over fifteen years constant ice-yachting upon the Hudson, in all sorts of weather and on all conditions of ice, I have yet to detect the slightest weak point in a vessel constructed like the Whiff, which boat is built even more strongly for her size than the majority of our ice-yachts.

"The proof of the pudding is in the eating;" and the strength of the Whiff was fully tested this winter in her trial trip, when, with four persons upon her, with a reefed sail, and in a gale of wind so that the windward skate was constantly raised 5 and 6 feet in the air, she sailed a distance of over 20 miles over a roughly frozen surface of ice mingled with 2 and 3 inches of snow, and made the last eight miles in 11½ minutes, and arrived home without a joint opened, a bolt started, or the slightest strain perceptible.

Of course there is a limit to the strength of all wood and iron; but for speed and strength combined (the true ice-yachtman's greatest aim and pleasure), I am confident that the Whiff is unequalled by any other boat of her size that has yet been constructed.

The true ice-yacht is built to obtain a high rate of speed upon ice; just as a trotting wagon is built to be drawn rapidly over a fairly good road. No one would justly condemn the construction of the latter, because, in a plowed field or stony lane, it did not answer as well as the stronger farm wagon or ox-cart; for the rough field is not its element. As with the trotting wagon, so with the ice-yacht. It is built for a certain purpose, viz., for speed, with all the strength compatible; not for strength, with what little of speed can be added thereto. One of the secrets of speed in an ice-yacht is a strong but lively and springy runner-plank, and the ¾ in. iron rod with which your correspondent trussed his plank was the cause of its twisting and eventually breaking; for the plank was thereby rendered so rigid, that, on receiving a hard blow or downward pressure, there was not the slightest give or spring to the plank to ease the front of the plow; and something necessarily had to break, even though it be of iron. The iron rod was bearing the whole strain, and snapped first; and the strain, then coming suddenly upon the plank with a jerk, completed the ruin of the latter.

The rod was an unwarrantable addition to the plans upon which our boats are constructed, and as set forth in your Nos. 1 and 63, and to which the whole disaster was doubtless attributable. I think it can be safely stated that your cor-

respondent, by the substitution of the long truss for the mast bench that he describes, has gained in useless strength at the sacrifice of speed. A good pine plank 3½ inches deep under mast bench, and carrying its strength almost the same to its outer ends, has proved, for a boat of the dimensions and weight of the Whiff, all that can be desired during the experience of nearly a score of years; and to-day, after many a rough and wild sail of the past winter, the Whiff, without the least repair or touch of any kind being given to her, is in as perfect order throughout as when she left the Centennial grounds.—I remain, very respectfully yours,

IRVING GRINNELL,
Com. New Hamburg Ice Yacht Club.
New Hamburg, N. G., N. Y., April 9, 1877.

THE EDSON RECORDING STEAM GAUGE.

IN the inquiry which follows the explosion of a steam boiler, usually the first question that is asked relates to the pressure of steam carried just previous to the casualty. In nearly every case there is always some one to testify that the gauge showed no extraordinary pressure, and when the condition of that instrument exhibits no fault, and no serious defect is discovered in the metal of the boiler itself, then the

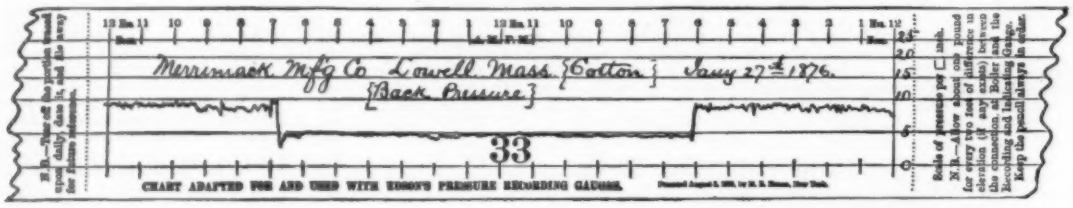
affair becomes "mysterious," and a legion of theorists come forward with electrical and other far-fetched hypotheses. Now, it is well settled that when a boiler explodes it does so because its weakest part is not strong enough to sustain the strain to which it is opposed; and it is equally well known that, under certain conditions, the steam pressure is liable to augment with great rapidity, and to subject the boiler to sudden and extreme stress. It will be seen, therefore, that the testimony of any one relative to the condition of the gauge a minute even prior to the explosion is not conclusive as showing the pressure at the moment of rupture; and when the witness is the engineer or fireman, who is most directly interested in the result of the investigation, evidence of such importance, based on memory, ought to be regarded with great caution. These facts, independent of others, are sufficient to indicate the value of an instrument which affords indubitable records of the steam pressure carried, up to the instant of explosion, and which inscribes its indications apart from the control, and, if need be, from the knowledge, of the person in charge of the boiler.

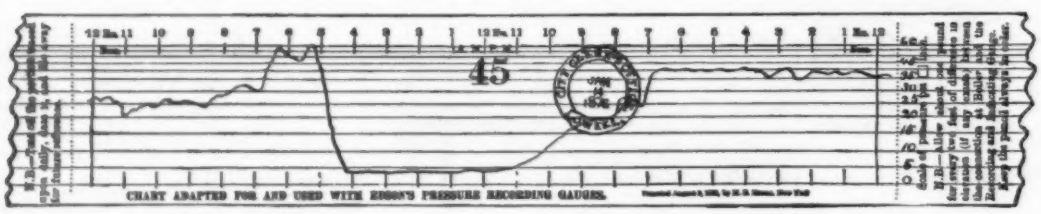
The Edson Recording Gauge, which we illustrate herewith, not only accomplishes the above, but it is an automatic historian of the life of the steam generator. Its records are traced with unfailing accuracy, and, when combined, exhibit the fluctuations of the steam pressure for every instant of the time during which the boiler has been in operation. Our engraving, Fig. 1, represents the instrument with sufficient clearness to render any detailed description of its mechanism unnecessary. It includes a hand and dial from which indications may be read as from the ordinary steam gauge. Eight-day clockwork actuates the apparatus, which causes the gradual passage of a strip of paper beneath a pencil point. This paper is marked off in hours, and each strip is divided so as to represent one day. The pencil has a vertical motion and is governed by the steam pressure, rising when the same augments, descending when it decreases. A scale is provided showing the pressure corresponding to the degree of ascent or descent. It is evident that so long as the pressure is exactly uniform the pencil trace will be a straight line, but when fluctuations occur then the line will become more or less sinuous. It is only necessary to note the height or depth of these sinuosities above or below a line representing the normal pressure which it is desired to preserve to see at once not only how much that pressure has been transgressed in either direction, but, by observing the position of the bend with reference to the hour marks, to perceive the exact moment when the fluctuation occurred. Or when the boiler pressure is permitted to range between given limits, the fact of the trace keeping within such boundaries, or exceeding the same, is at once shown. As the trace for each twenty-four hours is finished, the chart is removed and filed away and a blank one substituted.

Thus, the steam user has not only a complete record of his boiler, which will be of the greatest value not only in case of casualty, but in considering the necessity of the timely repairs necessary to prevent accident and to keep the boiler in proper condition. At the same time he has a perfect check on his engineer and fireman, and these employees are not even left the fragile excuse of not having noted the gauge, when the latter betrays their neglect in allowing pressure to run too high, because an electric alarm is added which rings out its warning the instant a dangerous pressure is attained. The construction of the instruments is exceedingly accurate, and the charts are specifically adapted to one gauge spring each, so that uniformity of operation under all circumstances is secured.

In order to show the work of the apparatus, we give herewith reproductions of three of its charts. No. 40 is from the White Star Line steamship Germanic. The fluctuations shown are attributable to the delays incidental to the steamer entering New York Harbor. In No. 33, from the Merrimack Manufacturing Co's cotton mills in Lawrence, Mass., back pressure is indicated from six o'clock one evening to seven the next morning. No. 45, marked "City Clerk's Office, Lowell," reveals an interesting record of neglect, and shows how nearly a "mysterious" boiler explosion was avoided. The fireman was ordered to carry 40 lbs. of steam, and it will be seen that he did not vary much until seven P.M., when he left the boiler to its own devices. The rapid falling of the pressure is shown. At about four A.M. this careful attendant probably woke up and urged his fires. Up goes the steam past 40 lbs., and up above 60, and then by noon it gradually comes down within safe pressure. The question was, How did the steam get to 60 when the safety valve was set at 40? Investigation followed, and it was found that the valve had been overloaded to 80 lbs., unknown to the Superintendent of Public Buildings in whose charge the boilers were placed. The gauge told that the fireman had suddenly subjected the boiler to the unwarrantable strain of 60 lbs. twice before seven A.M. An explosion might have followed, and then the theorists would have triumphantly asserted that pressure did not do it, because the valve was loaded to only 40 lbs.

It is not necessary to add much more in proof of the importance of this invention. It is a valuable safeguard for human life, a means of economy in fuel, it allows of the securing of any degree of heat, it is a check on the reliability of employees, an invaluable aid to the boiler inspector, it furnishes accurate data for scientific investigation, and it reduces insurance risks to a minimum. The Edson Recording Gauge Manufacturing Co. (limited), 91 Liberty street, New York city, may be addressed for further information.


Merrimack Mfg Co Lowell Mass {Cotton} {Back Pressure} Jany 27th 1876.
33
CHART ADAPTED FOR AND USED WITH EDSON'S PRESSURE RECORDING GAUGES.



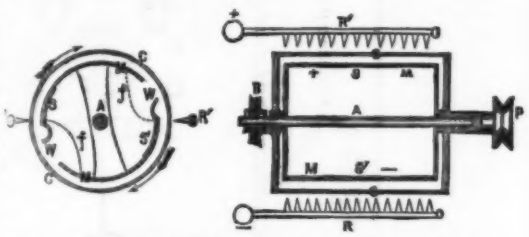
NEW HOLTZ ELECTRICAL MACHINE.

By Professor ELIHU THOMSON.

THE many advantages possessed by induction electric machines, over those producing electricity by friction, have caused the latter to be almost entirely discarded as a source of static electricity. Of these induction machines, the "Holtz" is, perhaps, the best known, and many modifications of this machine have been designed to render it self-charging, and constant in action. When, however, the plate form is adopted, the limit to the size of the revolving plates, with the ordinary materials and space that can be allotted, is soon reached. With glass plates the speed of running is limited by the fragile nature of the glass itself.

The form of Holtz machine presently to be described, it is believed, obviates these and other disadvantages, and affords at once a cheap, compact, and portable piece of electrical apparatus, capable of being run at a very high speed, and greatly increasing the electrical power of the machine.

The materials used in the construction are chiefly paraffined wood, and paper or cardboard, also paraffined. When wood or paper is thoroughly dried or baked, and, while still hot, immersed in melted paraffin at above 100° C. until soaked, it becomes, after cooling, one of the best non-conductors of electricity known. The wood so treated is very strong, and will not subsequently warp or change its form. It is, so to speak, completely waterproofed.



In the figure, C C is a hollow revolving cylinder of paraffined paper or cardboard, the ends being made of the same material, or of wood similarly prepared. This cylinder is revolved about a *fixed* axis, A, by the pulley P. The axis A is fixed to the frame of the machine at B, and is made of paraffined wood or other insulating material. It serves as a support for the stationary inner cylinder, M M, also of paraffined cardboard. The cylinder M M carries on its inner surface one or more pairs of what are commonly known as sectors or inductors, S S', consisting of strips of partially conducting material, placed opposite the outside rows of collecting points R R', and provided with the usual pointed projections turned toward the inner surface of the revolving cylinder C C. Parts of the inner cylinder M M, adjacent to the sectors S S', are cut away in a direction from S S' opposite to the direction of rotation of the outer cylinder. These open spaces are seen at W W. The open spaces or windows, W W, are not necessary, if the contour of the inner cylinder be that shown by dotted lines, *f f*. The supports for the various parts, as above described, are all thoroughly paraffined to insure complete insulation. The metallic collecting points or combs, R R', constitute the conductors or poles of the machine, + and —, respectively, or the reverse, the polarity depending on the original charge given to the machine. The charging is accomplished by holding an electrified body, as a rubbed piece of caoutchouc or vulcanite, opposite one of the spaces or windows W, as shown at E, at the same time that the cylinder C C is in motion, in the direction shown by the arrow.

The machine may be made self-charging by providing a small accessory cylinder, revolving opposite the points E, on an axis parallel to that of C C. The accessory cylinder is made of hard rubber, shellac, sulphur, or the like, and is constantly rubbed by an amalgamated cushion, as in the common frictional machine.

A machine constructed as above, with the cylinder about 7 inches diameter and 12 inches long, and run at a moderate speed, gives enough electricity to charge three 1 gallon Leyden jars to a tension of 1 inch in less than four seconds, and may be employed for every purpose where an abundance of static electricity is required.—*Franklin Journal.*

SEWERS.—Very valuable information on the subject of sewer gases was communicated by Dr. Frankland at the February meeting of the Royal Society. The direct connection of the outbreak of pestilential diseases with the exposure of a locality to the gases from sewers was shown by some remarkable instances. The conclusions from careful experiment are that the ordinary and proper flow of sewage does not so agitate the liquid that the gases will escape; but, if the flow is checked and the sewage stagnates, the deleterious gases will certainly be evolved. Hence it is of prime importance that a steady and even flow should be kept up at all times through sewers.

BORATE OF LIME FOR REFINING SUGARS.—The use of the monoborate of lime in sugar-refining prevents the formation of glucose, and diminishes the proportion of crystalline sugar going off in the form of treacle.—*Les Mondes.*

[JOURNAL OF GAS LIGHTING.]

PIPES FOR GAS AND OTHER PURPOSES.

(Continued from SUPPLEMENT No. 69.)

MAIN LAYING.

IN the laying of mains, certain mechanical appliances are necessary in addition to the manual labor employed. The apparatus denominated a three-legs, or shear-legs, is frequently adopted for raising and lowering pipes above 8 inches in diameter. This, stretching across the open trench, is shown in Fig. 48.

It consists of three wooden poles, usually of ash, from its toughness, 10 or 12 feet long each, tapering from one end to the other and averaging about 5 inches thick. These are

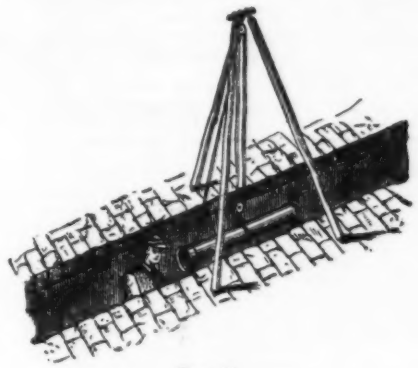


FIG. 48.

hooped with iron at both ends, and a wrought iron spike, being driven in at one of the ends, is made to project about 3 inches, in order to penetrate the ground, and prevent the slipping of the legs when fixed over the trench. The other three extremities of the poles are all secured together by means of a wrought iron pin or bolt, having a head at one end and a cotter at the other. This passes loosely through the three ends, allowing the pole to swivel across the trench, two at one side and one opposite. From the pin an iron link

FIG. 49.

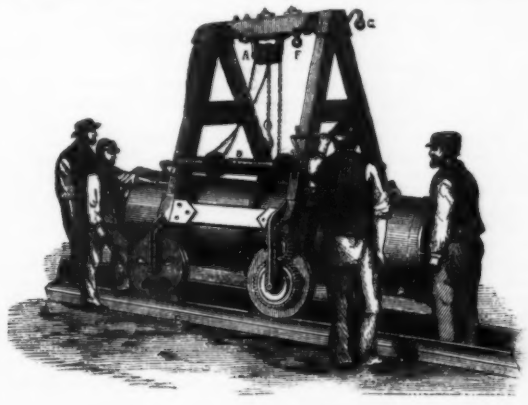


FIG. 50.

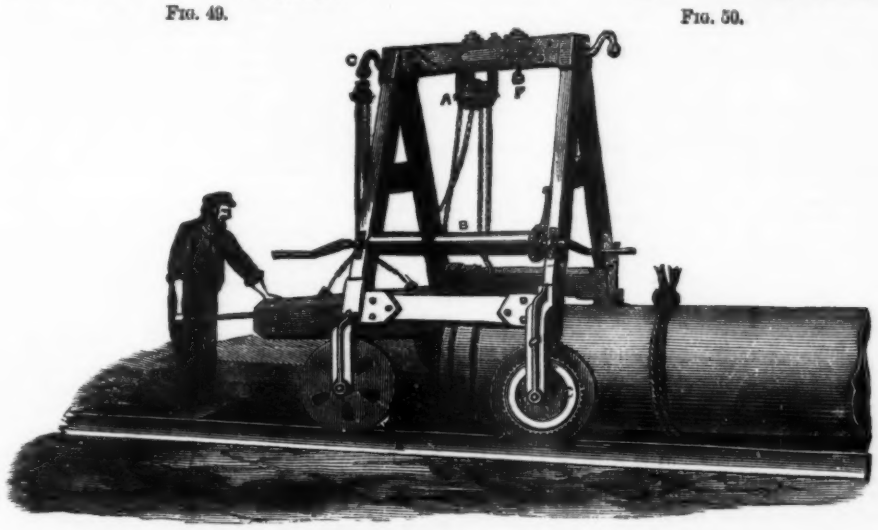


FIG. 51.

STOREY'S MACHINE FOR LAYING LARGE PIPES.

depends, and from this again is suspended the blocks and chain for raising and lowering the pipes in course of being laid. Another modification of the apparatus is to have the wooden framework rigid, and in form resembling a trestle, as in Fig. 49. To this is usually attached a winch, turned by a handle, for greater ease in manipulating large pipes.

The late Mr. Rafferty, of Manchester, some years ago, designed a very useful machine for main laying. Two sizes of this are employed by the corporation gas authorities in that city. One is intended for pipes from 10 inches to 16 inches and the other for pipes from 18 to 40 inches diameter. Their form and construction are shown in the accompanying engravings. The drawings are copied from a photograph taken as a 30-inch main was being laid. The machine is made to move on rails, laid about 6 feet apart, on each side of the trench. Fig. 50 shows the apparatus and the men engaged, the pipe-layer, or foreman, standing at the spigot end directing his assistants. A, the eccentric blocks; B, winch for raising or lowering the pipe; C, wheel and pinion for moving the machine; D, the yoke-rings to enable it to be drawn from one place to another; E, scotch to hold the machine fast at any desired point; F, ring for common blocks; G, the hook from which the tup for driving the pipe is suspended by a block and chain, and Fig. 51 the workman in the position of driving the pipe home. The latter drawing is intended merely to show the method of driving. Of course, in practice, the pipe is first lowered to the bottom of the trench or cutting, and the men take their places there also. The pipes are rolled on to a cross-plank clipped by a rope or chain, and then attached to the eccentric blocks to be taken to the part of the trench required. Five or six men can roll a pipe 20 inches in diameter, lay it in its proper place in the trench, and complete the joint, if turned and bored, in the short space of from six to eight minutes. With the use of this machine, mains of large size may be laid with half the number of men required to be employed when using the ordinary implements, and with more satisfactory results. We are fully convinced of the excellence of the arrangement, and recommend it to the attention of gas managers about to put down mains of large diameter. The maker of the machine is Mr. John Storey, of Manchester.—*Journal of Gas Lighting.*

ON WELDING.*

BY RICHARD HOWSON.

IN the paper which I had the honor to read at the last meeting of this Institution, I endeavoured to show that the *rationale* of welding, although it might be esteemed trivial in itself, had really a very important bearing on the subject of puddling, especially puddling by machinery on a large scale. In the discussion which followed, some criticisms fell from members, which induce me to claim the indulgence of the meeting for a few additional remarks, in order more clearly to elucidate the views then brought forward.

I drew attention on that occasion to the fact that the process of manufacturing wrought iron was, from beginning to end, a process of welding, whether it is effected by successive doubling or whether the so-called homogeneous process is adopted.

In both cases it was maintained that the presence of silica, or some equivalent flux, was an advantage in the whole series of operations, in the same manner that it is of use in uniting two pieces of iron in a smith's forge.

Mr. Bell took the ground, which others have also done, that a flux is not necessary. He instanced in the first place the case of platinum, which unites of itself, at a certain temperature, by pure metallic contact. Now nothing could better confirm the view which I then took than this example. Platinum is an unoxidizable metal, and, consequently, during the process of heating, no film of oxide is formed on its surface to interfere with its proper union. Where there is nothing present which requires fluxing, a flux would be quite superfluous. Iron, on the contrary, is a highly oxidizable metal, and its oxide, in common with those of all metals, is of a very refractory character when pure, although its affinities are such that a very small addition of silica imparts to it comparative fusibility.

This leads to the second remark of Mr. Bell, that it is not necessary in welding to add any flux—that iron, in fact, can be welded without the use of sand. In reference to this observation, I can only refer to my former remarks, the whole course of which distinctly implied that the outer skin of wrought iron and the interstices between its fibres consisted of cinder (where cinder was present), which was not a pure oxide but a basic silicate, which is equivalent to saying that it carried its own flux. In all the processes of manufacturing finished iron by piling, it is certain that no flux is added, but this is because sufficient is already present, being derived from the silicon contained in the pig iron, and from the silica and phosphoric acid which are always more or less mixed with the fettling of the puddling furnace. If I dwelt at unnecessary length on the frequent use of sand in the operations of forging, it was only for the purpose of illustrating the utility of that material, and tracing its mode of action in the larger operations of puddling, hammering, and rolling.

Referring now to the case of platinum, it follows that if cast steel, or any other metal which has been fused and contains no cinder, can be preserved from oxidation during the process of heating, that is to say, if the surfaces to be united can be made to come together in a perfectly clean state, a sound weld ought to be obtained, and the addition of a flux would be not only superfluous, but injurious. It is known that two surfaces of a soft metal, such as lead, may be united even cold in this manner. In the case of cast steel, where heat is required, the following experiment is conclusive: Two pieces of cast steel were planed and filed each on one face perfectly flat and true. The two clean surfaces were then placed on one another; the pieces were bound together with soft iron wire, and the edges luted round with fireclay to prevent the entrance of air. After being brought in a smith's fire to a sub-white heat, the two were united with half a dozen blows of a sledge hammer. The weld is perfect—so thorough, indeed, that it cannot be detected when broken through. Its course can only be guessed at by following the indication on the rough outside edges.

We have here an instance of union exactly parallel to that of platinum, by unalloyed metallic contact. On the other hand, in order to exhibit the influence of an intervening refractory oxide, the following experiment was tried: Two pieces of cast steel were prepared by planing and filing exactly as before, but the two level surfaces were painted with a thin film of jeweler's rouge, which is a tolerably pure form of peroxide of iron. A small well was also drilled in the middle of one piece, which was filled with the same rouge. The same process of binding, luting, heating, and hammering, was then carried out, and the result is a bad weld, or rather no weld at all.

On splitting open the two faces, which was readily done with a chisel, and examining their condition, the oxide in the well appears to have been imperfectly fused, while there are indications that the thin film has become partially reduced to the state of wrought iron by the action of the carbon in the steel, the oxygen no doubt escaping. However this may be, the experiments affords an exact parallel to what takes place when the attempt is made to weld two pieces of cast steel, by heating them separately in a fire without any flux. In the latter case, the oxide formed by the action of the blast would be quite as pure as the rouge which in the experiment was applied artificially, it would be equally refractory, and there would be more of it. The utility of a flux is here self-evident, and need not be dwelt on further. In the case of wrought iron, as already explained, there is not the same necessity for its employment, as it is already present in sufficient quantity, unless the iron is of an unusually dense character.

MACHINE PUDDLING.

Referring now shortly to the subject of machine puddling, I propose only to consider it strictly in its relation to the foregoing conclusions. The more refined chemistry of the process I leave to abler hands.

The most suitable lining for a revolving furnace, in fact the only admissible one, so far as is known at present, is the purest oxide of iron that can be procured. It is, indeed, somewhat surprising to find a single material combining in itself so many good properties, and that no substance is capable of replacing it in its chemical adaptation for eliminating all the impurities of pig iron. It is, however, highly refractory, and this refractoriness, although an advantage in one respect, acts unfavorably on the final result. In charging the furnace, a small quantity of impure silicious cinder is usually thrown in, so as to assist in procuring a certain degree of fusibility, and enable the iron to revolve in a liquid bath; but it is generally considered that, the purer the cinder, the better is the puddled product. Hence comes the practice of applying an intense heat by which means alone a sufficient liquefaction of the fettling is procured in order to do its work effectively. The consequence of this is that, although the iron may be thoroughly puddled when the heat is finished, the ball contains a cinder which, being comparatively infusible, sets readily on exposure to the cold atmosphere. I have before pointed out that shingling a puddled ball is essentially a process of welding, and here comes into play the fact that a ball will not shingle satisfactorily, especially if of large size, unless its contained cinder has a certain degree of liquidity. In order to procure a fine quality of iron, a pure fettling is employed, and the heat is urged up to a point which rapidly destroys the furnace, while it often happens that, when the ball comes to the hammer, it drops in pieces in consequence of the setting of the cinder before it can be squeezed together.

It is true that the same untoward event will sometimes occur in ordinary puddling, but this is on a smaller scale, and the puddler usually takes care of his heat, which does not affect his furnace injuriously to any great extent; besides which, if it did, one furnace spoilt, he would ask for another, which he sometimes does. The destructive action of a high temperature on the revolving furnace is also accompanied by another evil, viz., an excessive and costly consumption of fettling, owing to the entire inner circumference being exposed to flame.

These are some of the difficulties of machine puddling, but I believe they are the only really formidable difficulties. The common process of puddling has been established by long usage, but we should not forget that its introduction also was beset with many troubles. We have only to glance over the abstracts of patents, from the period when sand bottoms were used up to the present, to note the variety of schemes which have been attempted to improve it. Among these inventions there is one class which I would here refer to, as it is kindred to the subject in hand, viz., that of chemical mixtures, commonly called physic. On examining this long series of specifications of inventions applicable to puddling, almost every element will be found named, and innumerable combinations, supposed by the patentees (as it is usually expressed) to purify the iron. Many of these nostrums are absurd enough; others are of problematical value. There are, however, doubtless, a great number

* Paper read before the Iron and Steel Institute.

which are more or less useful, but, with the exception of those which are intended to give the iron a steelly nature, it may be questioned whether any of them act chemically on the metal to improve its quality beyond that which the fettling alone can effect without admixture. Their utility probably consists simply in this, that they assist in imparting that fluidity to the cinder which is so essential in giving soundness to the hammered bloom.

According to the instruction usually specified in these inventions, the proper time for adding the physic seems to be towards the end of the process, and there is good reason for this, because if it were applied early it would tend to scour the fettling, whereas, if applied late, it unites at once with the cinder which is already melted, a great part of which will be carried away by the puddled balls. It is a question whether the adoption of this method of working in revolving furnaces would not enable the excessive heat to be somewhat moderated. A few handsfull of sand thrown in just at the point when the iron is ready to ball up, always facilitates the shingling process, and tends to produce a solid bloom, without affecting the iron, so far as I am aware, injuriously.

In reference, therefore, to the horror usually expressed at the mention of sand in the puddling furnace, it ought to be distinctly understood that it is only objectionable in the process for the very same reason that it is beneficial in the ball, viz., that it promotes fusibility. In the former case, it acts destructively on the lining, and, in the latter, it facilitates the union of the particles of iron. If it be supposed that the metal itself suffers detriment from its presence, the two following experiments, communicated to me by Mr. Stead (of the firm of Pattinson & Stead), and suggested originally, I believe, by Mr Williams, seem to affirm the contrary.

A small quantity of Cleveland pig, accompanied with some cinder, was poured in a liquid state into a hot crucible; a cover was then put on the crucible, and the whole was shaken up violently for a quarter of a minute.

No. 1 experiment, the cinder consisted of mill tap alone. In No. 2 it consisted of 80 per cent. mill tap and 20 per cent. sand. The analysis of the metal after each operation was as follows:

	No. 1 per cent.	No. 2 per cent.
Carbon	2·40	3·00
Silicon	trace	trace.
Phosphorus	0·13	0·04

It appears that in eliminating the phosphorus, where the real difficulty lies, the best result was obtained where sand was present. It may here be noted that the wonderful short time in which this elimination was effected from pig containing not less than 1·25 per cent. of phosphorus, confirms the fact, if confirmation were needed, that agitation, not less than heat, is an essential of effective puddling. Hence it is again a matter worth consideration, whether more perfect mechanical agitation may not to some extent be a substitute for, and tend so far to moderate, the excessive and destructive heat.

Machine puddling in the revolving furnace has during the last few years been on its trial, and has had a hard struggle for the mastery, to which it is still destined to attain. I have endeavored to indicate where the great difficulties lie, and how they be to some extent obviated by varying the mode of working, but it is quite possible still more to obviate them by improvement in construction. With regard to the practicability of producing finished iron without piling, I have only to refer to the results which Messrs. Hopkins, Gilkes & Co. have obtained to show that, at all events, with certain classes of manufacture, this point may be considered established. Whether it will be found expedient to work in masses of extremely large dimensions, or not, is a question which only the construction of costly machinery can decide.

LUBRICATION.

By Professor R. H. THURSTON.

WHEN two surfaces are rubbed together, however smooth they may be, a resistance is met with which is called friction (from the Latin *frico*, to rub). When a current of fluid moves in contact with the surface of a solid or with a mass of other fluid, a frictional resistance is also produced. In the former case, this resistance is due to the interlocking of minute asperities of surfaces and their forcible removal. The smoother the surface, the smaller these asperities and the less the resistance. In the second case, the resistance is due to the production of little eddies and of currents within the mass of fluid. It is seldom due to real rubbing of fluid against solid. Fluid friction generally produces a much smaller resistance than the friction of solids.

The effect of friction is to produce abrasion and wear of solids and, with both solids and liquids, to effect a waste of the power which is expended in producing motion. In both cases, all power thus wasted passes away in the form of heat, in the proportion of one British unit for each 772 foot pounds of work; and the existence of this cause of waste is objectionable, not only because of the waste of power, but because the production of heat, in such considerable quantities that it cannot be disposed of promptly by conduction to the neighboring solids or by radiation into space, results in so great an elevation of temperature at the rubbing surfaces that inconvenience and, sometimes, danger may arise by the heating of the lubricant and abrasion of parts.

Lubrication is the means usually adopted to reduce losses of power and the evolution of heat. It consists in the interposition, between the surface of contact, of substances having a lower coefficient of friction than the rubbing parts.

The coefficient of friction is a figure which expresses the proportion which the resistance to the sliding bears to the force with which the two surfaces are pressed into contact. A very low value would be $\frac{1}{20}$, or 0·05; a usual value is $\frac{1}{10}$, or 0·10; a very high value is $\frac{1}{4}$, or 0·25. In some cases, as where journals are "cutting," this figure becomes very high, and even so great that, in many cases, the pressure imposed would be insufficient to produce sliding. Journals are sometimes "seized," and fairly welded or soldered into their bearings. Solid surfaces, dry, give about 0·20 or one-fifth.

Since both resistance and the development of heat are to be prevented, a good lubricant should have the following characteristics: (1.) Sufficient "body" to keep the surfaces from contact under maximum pressure; 2.) The least viscosity consistent with (1); (3.) The lowest possible co-efficient of friction; (4.) The largest capacity for receiving and carrying away heat; (5.) A high temperature of decomposition; (6.) It should vaporize at high temperatures rather than decompose and burn on.

In some cases, friction rolls or wheels are substituted for rubbing surfaces, and the resistance is then "rolling friction," which is not properly friction at all.

Lubricants may be either solid or fluid; the former are to be used on journals carrying very heavy loads, and the latter under light loads. Thus, graphite is used in the former case and the oils in the latter. Tallow is used for pressures too great to be sustained by the oils; and, for extremely light work, as in watches, the most limpid of oil is required.

The solid lubricants, in the order of their frequency of application, are: tallow, lard, soap, metallic compositions, sulphur, graphite, asbestos, soapstone, lampblack, carbonate of lead ("white lead").

The metallic compositions and some special solid preparations, as Babbitt or anti-friction metal and metaline, are permanently fixed in the bearings as a lining; and their effect is to substitute, for the hard, rigid, and resisting surface of the metal of the bearing, a material which more readily adapts itself to the form of the journal and which has a lower co-efficient of friction together with sufficient conductivity for heat. Many solid compositions are used on the bearing by interposition.

Graphite should only be used in the state of an impalpable powder and should be free from acid. A mixture of tallow, graphite, beeswax, and white lead, all together, or two or more together with water, is used for the journals of car-axles on railroads. A mixture of palm oil, tallow and lime-water, or of cocoa or palm oil with water and caustic soda, is still better. Eight parts of wax of the bayberry, and one of graphite, is excellent.

The fluid lubricants usually employed are the cheaper and more common fixed oils. (A siccative, or drying, oil is unfit for lubrication.) Sperm, whale, lard, neats-foot and tallow oils; glycerin; olive, rape seed, cotton seed and other vegetable oils, and the heavy shale and petroleum oils are most used. Water is often used, but its value is that of a conveyer of heat rather than a reducer of friction. For wooden bearings under water, it is the usual lubricant.

In the "Palier-glissant" of Girard, the journal is supported upon a cushion of water, the waste from which is supplied by a force pump. Among fluid lubricants, sperm and lard oils, heavy shale oil, and crude heavy petroleum are most used for heavy journals. The latter oils are rapidly superseding the more expensive animal oils. Mixtures of the two classes are much used. The mineral oils have a great advantage in their freedom from tendency to oxidize and "gum" after remaining a considerable time on the journal or exposed to the air.

The pressure which can be borne by a lubricant depends upon the character of the frictional surface, as well as upon that of the lubricant itself, and also upon the velocity of rubbing. The maximum for solid lubricants is unknown, but is probably proportional to the value of the elastic limit for the material or for that of the metal of journal or bearing —whichever may have the lowest value. For steel surfaces, lubricated with the best sperm oil and moving slowly, 1,200 pounds per square inch has been found admissible. Under the pivots of spring bridges, pressures of several thousand pounds per square inch have been used. For iron journals, 800 pounds should never be exceeded.

The following formulas were made, the first two by the writer and the last by Prof. Rankine, respectively, to determine the maximum allowable pressures when the speed of rubbing was known:

$$P = \frac{60{,}000\ l.\ d.}{V} (1), \qquad p. = \frac{60{,}000}{V} (2), \qquad p. = \frac{44{,}800}{V} (3);$$

in which P is the total maximum pressure on the bearing in pounds, l and d its length and diameter in inches; V is the velocity of rubbing in feet per minute, and p is the maximum allowable pressure in pounds per square inch of longitudinal section of the journal. The first two formulas were determined by experiment upon the journals of naval steam engines, the last by observing the performance of locomotives. The exposure of the latter to dust compels the adoption of large surfaces. In many cases, engineers give a length of journal equal to twice its diameter, and find that lubrication gives no trouble. A better practice is to calculate the proper length of the journal from the special condition of the case, as by use of formula (1) thus:

$$l. = \frac{PV}{60{,}000\ d.} (4).$$

For line-shafting, journals are often made four diameters in length by the best builders.

Messrs. King, Stivers and Price, of the United States Navy, reported the following as pressures on the lubricants named at a speed of 200 feet per minute: best sperm oil, 75 lbs.; lard, 55; best mineral oil, 65; highest, 30. They gave the following as the temperatures of congelation:

Oil.	Temp. of incipient Congelation.	Temp. of Solidification.
Summer Sperm Oil	66° Fahr.	56° Fahr.
Winter " "	48° "	30° "
" Lard "	40° "	25° "
Best Mineral "	43° "	30° "
Very light "	18° "	Below 0° "

Lubricants as found in the markets are variable in value, as in cost; and neither buyer and seller can usually form an idea of their real relative or actual intrinsic values. The most expensive are often found by test to be the least valuable. The appended tables give the results of experiments made to determine the relative and the cash value of oils in the Mechanical Laboratory of the Department of Engineering of the Stevens Institute of Technology.

Experiments upon the value of lubricants were made by Amontons as early as 1699, and by many physicists and engineers since. Coulomb, Rennie, and Morin are the most generally recognized authorities. The following are the values of the co-efficient of friction, F., with different lubricants, according to Morin.

CO-EFFICIENT OF FRICTION.—MORIN.

Material.	F.
Wood on wood without lubrication	0·25 to 0·50
" " lubricated with soap	0·04 to 0·20
Metal on metal unlubricated	0·50 to 0·60
" " greased	0·20 to 0·25
" " wet with water	0·25 to 0·35
" " oiled	0·15
" " freely lubricated	0·05

The following table represents the results of experiments on the best known lubricants as obtained by the writer, by the method above described, using great care in selection and driving the rubbing surfaces at a mean speed of about 750 feet per minute. This speed is very high and is purposely chosen; otherwise, the trials under moderate pressures might occupy days. The table is valuable as representing the mean value of trials of nearly all the good oils in general use.

AVERAGE OF COMMERCIAL OILS.—THURSTON.

Pressure.	Endurance. Minutes.			Rise of Temperature.	Co-efficient of Friction.
Per square inch.	Ave.	Min.	Max.		
8 lbs.	82	17	411	167° F.	0·20
16 "	29	9	97	212	0·16
32 "	10	2	19	228	0·12
48 "	8	1	13	228	0 10

The following are the results of trials of fair samples of well known kinds of lubricants at a speed of rubbing surfaces of 750 feet per minute:

CO-EFFICIENTS OF FRICTION AND ENDURANCE OF LUBRICANTS.—THURSTON.

Name	Pressure.	Endurance.	Rise of Temperature.	Co-efficient.
Sperm (Winter) Oil	8 lbs.	111 Min.	230 F.	0·13
	16 "	29 "	225 "	0·10
	48 "	9 "	195 "	0·08
" (Summer) Oil	8 "	165 "	170 "	0·13
	16 "	33 "	215 "	0·11
	48 "	7 "	265 "	0·10
Lard Oil	8 "	77 "	175 "	0·16
	16 "	27 "	250 "	0·12
	48 "	11 "	260 "	0·07
Neat's foot Oil	8 "	106 "	205 "	0·15
	16 "	31 "	275 "	0·10
	48 "	6 "	190 "	0·10
Olive Oil	8 "	83 "	170 "	0·13
	16 "	41 "	245 "	0 10
	48 "	14 "	240 "	0·06
Cotton Seed Oil	8 "	107 "	185 "	0·16
	16 "	45 "	275 "	0·12
	48 "	12 "	310 "	0·07
Palm Oil	8 "	49 "	195 "	0·17
	16 "	15 "	235 "	0·13
	48 "	9 "	295 "	0·07
Castor Oil	8 "	45 "	160 "	0 19
	16 "	35 "	180 "	0·11
	48 "	11 "	375 "	0·07
Fish (Cod) Oil	8 "	40 "	200 "	0·15
	16 "	14 "	175 "	0·12
	48 "	9 "	220 "	0·07
Crude Mineral Oil	8 "	129 "	105 "	0·10
	16 "	97 "	285 "	0·10
	48 "	5 "	270 "	0·10

To obtain the best results, oils of little body should be supplied to the bearing with the greatest possible regularity and with equal care, to avoid too great and too small a supply. The least that will be safe is best. Heavier oils should be supplied more freely, and tallow should be fed as fast as the journal will take it.—*Polytechnic Review.*

INVENTIONS OF THE CENTURY.

[Abstract of a lecture by Prof. PLINY E. CHASE, before the Franklin Institute, March 6, 1877.]

YOU will not expect me to rehearse in three lectures any considerable portion of the lessons which could be learned by six months' study of the great Exhibition; but you may, perhaps, be interested in briefly reviewing a few of its most obvious teachings. I will ask you to-night to go back, in imagination, to the "good old times" of our grandfathers and great-grandfathers; to the generation which rejoiced in the enterprise of Franklin, who, as Deputy Postmaster General, had established a fast mail line, enabling a merchant or a stockbroker or a lover, in Philadelphia, to send a letter to New York and get an answer in a week. There were no friction matches then. Man, as a cooking animal, had so far advanced from savagery as to substitute the flint and steel and tinder box for the friction of two pieces of dry wood, as a means of procuring the fire that he needed. Matches, dipped in sulphur, served to start a flame from the tinder box.

THE CHEMICAL LAMP.

The German chemist, Döbereiner, found that platinum sponge *occludes*, or shuts up, many times its own volume of hydrogen. The rapid vibration or the gaseous particles being thus greatly concentrated, the frequent collisions raise the platinum to a glowing heat, which inflames the gas that surrounds or plays upon it. This discovery led to the invention of his chemical lamp, which is still an interesting toy for the laboratory or study, but not fitted for general use. It furnished, however, an admirable illustration of the great principle of vibration, to which modern research points as the probable origin of all forms of force and motion.

THE FIRST MATCHES.

The first chemical matches were often sold at from six to ten cents apiece. They were tipped with a mixture of chlorate of potash and sugar, or some other substance rich in carbon, and accompanied by a vial of sulphuric acid. When the match was dipped into the acid it took fire. Amorphous phosphorus was afterwards substituted for the acid, thus furnishing substantially the same combination that is used in the modern safety match. In 1829, John Walker, a chemist of Stockton-upon-Tees, dispensed with the bottle by including phosphorus in the mixture for the tips, and igniting the match by the friction of sand paper. This was the "lucifer" match, which interested Faraday so much that he sought to confer a great public benefit by promoting its introduction into general use. The various forms of friction match, with which we are all familiar, are merely modifications of Walker's lucifer. Coston's telegraphic night signals, which were in the Centennial Exhibition, are fired on the same principle.

ORIGIN OF GAS LIGHTING.

A century ago, the oil lamp and the tallow dip, the latter being by far the more common of the two, helped to make darkness visible. In 1786, the Scottish lord, Dundonald, distilled coal and constructed an apparatus, merely as a curiosity, for burning the escaping gas. His canny workmen used the waste gas for light. In 1792, Murdoch began his attempts to introduce gas for lighting factories, but for several years his efforts met with little success.

Westminster bridge, London, was first lighted with gas in 1813, and the neighboring streets in 1814.

ORIGIN AND PROGRESS OF THE TELEGRAPH.

In 1790, there were but twenty-five post offices in the United States. Even so lately as 1836, the postage on a single half ounce letter was twenty-five cents for four hundred miles or over. Electricity was not impressed into the postal service by Prof. Morse until 1843. Prof. Henry's discoveries, which rendered practical telegraphy possible, began in 1830. The first efficient submarine link in Puck's "girdle round the earth," was laid in 1851, between Dover and Calais; the first Atlantic cable in 1858. Now, through the judicious study of the effects of combined and superposed vibrations, we have the duplex and quadruplex telegraph, and the telephones of Gray and Bell. There is good reason to believe that the te'ephones may be so perfected as to enable us, without limit of distance, to send an indefinite number of messages, at the same time and in opposite di rections, over a single wire. Already, conversation has been carried on through a wire of over one hundred and fifty miles, so that the words were distinctly audible, and the voices of different speakers were readily recognized. Music has been transmitted from Chicago to Detroit, a distance of 284 miles, the notes being as clear and distinct at the end as at the beginning of their telegraphic journey.

ORIGIN OF AGRICULTURAL AND TEXTILE MACHINERY.

The granaries of the world are largely supplied by the crops of our teeming Western prairies. The "staff of life" is cheapened by the improved drills, plows, cultivators, mowers, reapers, and threshers, which enable our farmers to cultivate their immense fields and gather their bounteous harvests. The wooden plow, in the Tunisian department of the Exhibition, was nearly as efficient as the one which was used by our great-grandfathers; the present "header," for gathering clover seed, contains the only contrivance which they knew for rapid reaping. The header is, substantially, the same as the machine which was used by the Gauls, in the first century of the Christian era, having a comb in front to strip off the ears of wheat, and pushed by an ox. It received no material improvement until Ogle invented the reciprocating knife in 1822. McCormick's reaper was not patented until 1834.

Our great-grandfathers rejoiced in leather aprons and homespun dresses. The hand-loom was a familiar household implement; the setting of hand cards enabled farmers' children to earn many an honest penny during the long but cheerful winter evenings that they spent in the chimney corner. Hargreaves patented his spinning jenny in 1770; Arkwright's contested patents, which enabled one man with a machine to do as much work as 130 men could do by manual labor, were not sustained until 1785. It would require 40,000,000 laborers to do the spinning which is now done in England by machinery alone.

Samuel Slater, who was apprenticed at the age of 14 to Jedediah Strutt, Arkwright's partner, made such improvements that he was intrusted, before he came of age, with the supervision of a new mill and the construction of its machinery. Almy & Brown were then about erecting a factory at Pawtucket, in which they offered Slater an interest. He accepted the offer, but the rigid British laws against the emigration of artisans prevented his taking any machinery or drawings with him. But his capacious head held all that he needed, and in 1790 he started the first successful cotton mill in the United States.

While constructing his machinery, Slater wished to obtain twilled cards of a pattern that had never been made in America. Pliny Earle, who agreed to make them, used two needles inserted in a bit of wood, to prick the holes in the leather into which the carding teeth were to be set. The tediousness of the operation led him to the invention of a machine which is still in use, and which, while it performed the work more satisfactorily, saved the labor of sixty men.

In order to prepare the cotton for carding, it was necessary to separate the fibre from the seed, a tedious process, especially with green seed cotton, which was the best variety. The cleaning of a single pound was considered a good day's work for a negro. This labor, added to the costs of cultivation, transportation, manufacture, re-shipment, commissions, and mercantile profits, made even the coarsest cotton goods expensive. Whitney's cotton gin, which was completed in 1793, raised the value of cotton plantations from fifty to one hundred per cent. Judge Johnson said, "If we should assert that the benefits of this invention exceed one hundred millions of dollars, we can prove the assertion by correct calculation." All the emolument Whitney received for this immense benefaction was $50,000 from the State of South Carolina, a tax of two shillings and sixpence levied for five years upon every saw used in North Carolina for ginning cotton, less the collection expenses, and some *promises*, which were never fulfilled, from other States. A large portion of the money which was thus obtained the inventor was obliged to spend in vexatious lawsuits.

The increasing demand for machine cards, consequent on the reductions in the cost of cotton goods, stimulated mechanical ingenuity to devise means for their more rapid production. Eleazar Smith invented a machine which would pierce the leather, cut the wire, bend it into proper shape, or both bend and set it, provided the tooth was straight. But, in order to furnish the requisite resistance in the carding process, it was necessary that the tooth should be so bent as to form a knee; and, after numerous vain attempts to set a bent tooth, Smith abandoned his undertaking. Amos Whittemore had been experimenting in the same direction, and, hearing of Smith's machine, he asked if he would sell it. A price being soon agreed upon, Whittemore took his purchase home, and the thought is said to have come to him, in a dream, that it would be just as well to bend the tooth after it was set, as to set it after it was bent. He accordingly added a simple bending die, took out a patent, and sold the right for $150,000. It was afterwards re-purchased by his brother Samuel.

The rapid increase in the production of plain fabrics, consequent upon these inventions, was accompanied by improvements no less wonderful in the weaving of ornamental designs. The warp threads were at first removed by treadles, the design being limited by the number of treadles that one man could work. "Draw-boys" were next introduced, who operated design cords which were fastened to the side of the loom; but the constrained position that they were obliged to keep ruined their health in a few years. Vaucanson introduced tambour machines, which were subsequently improved and finally perfected by Joseph Marie Jacquard, who reduced the roller to eight sides, which carried an endless chain of cards, pierced with holes so arranged as to allow the passage, at the proper moments, of wires connected with the warp threads. The Lyons silk manufacturers wove a portrait of Jacquard in his workshop, which required 24,000 cards, each card being large enough to receive 1,000 holes.

William H. Horstmann first introduced the Jacquard loom in America, in 1824. In 1837-8, his son, William J. Horstmann, manufactured power looms of his own designing, and employed them for narrow textile fabrics. The complication, delicacy, and accuracy with which the mechanical fingers and scissors and plyers of the card-setting and ornamental-weaving machines do their appointed work, entitle them to rank among the most wonderful triumphs of human skill and creative genius.

In order that the products of the loom may find a ready market, it is desirable that they shall be clean, and that their colors shall be "fast." Both of these ends are secured by the use of a very cheap soap, of which there are specimens on the table. You see that it is a very hard soap when in its most compact form, and that it looks very much like bottle glass. It is at once a glass, and a salt, and a soap, being the silicate of soda, or soluble glass. If it is allowed to run from the furnace into water, it crumbles into a coarse powder, which can be dissolved in boiling water, forming a soapy solution, which may be used for washing, for taking the place of resin in common soap, for forming artificial stone, for fire proofing garments or scenery, for a mordant in fixing dyes, for lining coal oil barrels to prevent leakage, and for various other purposes.

Fibres may be felted as well as woven. The true felting process, which you can see in any factory where wool hatbodies are made, requires animal wool or hair. You may learn why the animal fibres tend to cling together, by working a hair lengthwise through your fingers. You can readily move it in one direction, but not in the other. This is due to little protuberances on the surface of each hair, all pointing in one direction, and the interlocking of those protuberances gives considerable strength to the bocking or other felted product.

Paper is a sort of felt, but the adhesion of its fibres is mainly due to a kind of paste. The "mammoth ream," with material sufficient for 500,000 sheets of notepaper, and the general American display of paper, in all the principal styles of manufacture, attracted great attention from the foreign visitors to the Exhibition. The parchment papers, suited for bookbinding—the paper imitations of silk and leather, for hangings and other purposes—the great variety of applications of papier-mâché and carton-pierre, the "matrix" for stereotyping any required number of duplicate forms to be used in printing newspapers—represent only a few of the late inventions in this single line of manufacturing industries. By means of the continuous rolls, the cutters, the cylinders, the flexible matrices, and the webs, the clumsy and tedious process of forty years ago have given place to fast presses that are capable of printing a mile of newspapers per minute, throwing off the printed and folded sheets as fast ac two active boys can carry them away.

SUNBEAMS FROM CUCUMBERS.

Those of you who have read Gulliver's Travels will remember that the philosophers of Laputa were represented as engaged in endeavors to extract sunbeams from cucumbers. Can you imagine any idea more absurd? Can you not picture to yourselves the smile of satisfaction that lighted Swift's face as he penned the keen sarcasm on the philosophical speculations of his day? Yet, in science as in religion, we may often apply the maxim, "*credo quia impossibile est*"—its very impossibility makes it credible. The Laputan dream has been literally fulfilled; for if you gather a cucumber that has been exposed to the strong sunlight, take it into a dark room, wrap it in paper that has been prepared for photography, and shield it in all possible ways from external light, the delicate vibrations which have been absorbed will again be given forth, imprinting a distinct image of the cucumber on its sensitive wrapper. In connection with this fact, it may be well to remind you that, although Davy and Niepce had developed camera pictures, and Daguerre had made them permanent, the limning sun took its first portraits in America.

ORIGIN AND PROGRESS OF THE STEAM ENGINE.

Such are a few of the inventions which have contributed to the marvelous physical progress of the past century. From the many others I will select but one: the one which is, in many respects, the most important of all: the steam engine. Hero, of Alexandria, invented the eolipyle, which remained, for ages, an unsuggestive toy; the Marquis of Worcester described forms of apparatus by which steam could be applied to useful work; Savary, Newcomen, and Crawley made pumping engines for the drainage of wells and mines; but it was left to the ingenuity of Watt, by a series of improvements which were completed in the year of our national birth, to give us that mighty instrument of unwearying and unlimited toil which has wrought a revolution in our homes, in our workshops, on our farms, on our highways, in the bowels of the earth, and on the face of the mighty deep. Steam was first applied to cotton machinery by Arkwright in 1785; to sawing stone and grinding plaster, by Oliver Evans, in Philadelphia, about the same time; to a boat on the Forth and Clyde canal, by Symington, in 1802; to river navigation, by Fitch, Stevens, Evans, and Fulton, between 1804 and 1807; to a road engine or locomotive, in 1805. Stephenson's "Rocket" first drew a train of cars at the opening of the Liverpool & Manchester Railway in 1829. The first century of this monarch's sway has ended, and through its instrumentality the capacities of mechanical industry have been increased more than tenfold. Machinery is now doing more work than the whole population of the globe. The beautiful engine in Machinery Hall, which accomplished, so easily and so quietly, a task such as had never before been witnessed, may therefore be fitly remembered as the center of our Exhibition, which worthily and suggestively exemplified "the inventions of the century."

[The lecture was copiously illustrated by experiments, specimens of materials and fabrics, and lantern pictures.] —*Franklin Journal.*

MORDANTING COTTON FOR ANILINE DYES.

THE cottons are prepared for four or five hours in the fourth of their weight of sumac (or, much better, good pale myrabolans), working in the cold, that the yellow coloring matter of the sumac may not take on the fibre.

The goods may then be dyed in the aniline color beck, to which a little soap has been added.

If it is not desired to use soap, as *e.g.*, for blues which have to be acidified, the goods, after treatment with sumac, are steeped for one hour in a solution of—

Stannate of soda	2 lbs. 3 ozs.
Water	87 quarts.

Rinse and dye.

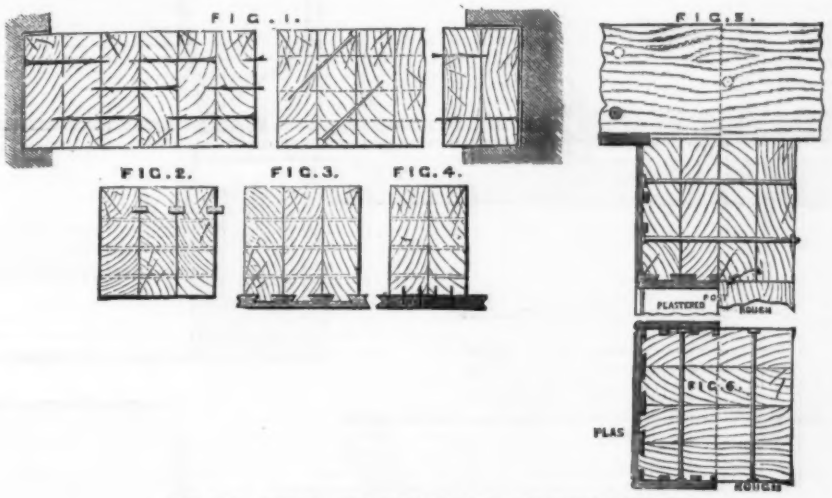
[N. B.—Stannate of soda can very rarely, if ever, be safely applied to goods containing wool or worsted, they seldom escape being more or less blackened.]

A NEW RESPIRATOR FOR FIREMEN.

AN ingenious respirator for enabling firemen or others to enter and remain in places filled with smoke or gas, or where, under ordinary circumstances, life would be impossible, is, according to the *Scotsman*, about to be adopted by the Edinburgh Fire Brigade. The respirator consists of a tube of much lightness combined with great strength, having inserted near one end a small tin case containing two peculiar india-rubber valves, the one for inhaling and the other for exhaling air. The end of this tube, which has a mouthpiece, is cast over the fireman's shoulder, the other being left in the open air; and an india-rubber spectacle mask, capable of being moulded to fit any cast of features, having been placed over the eyes so as to compress the nostrils, the fireman is ready to enter without fear the most vitiated atmosphere. With this simple apparatus burning buildings, gasholders, sewers, cesspools, vats, etc., can be entered without the slightest danger from suffocation.—*Pall Mall Gazette.*

PLAN FOR FIREPROOF FLOORING.

MESSRS. EVANS & SWAIN, of Southampton Street, Strand, London, have recently brought into notice a system of so-called fireproof construction which possesses several features worthy of commendation. The system as applied by them to the floors of buildings consists simply of close timbering, instead of the use of joists and flooring; in other words, the joists, instead of being spaced at some distance apart, are laid closed together, so that no air can penetrate at the joints. These joints are either spiked together or connected by screws, and if thought necessary dovetailed pieces introduced. As a further protection, the lower surface of the timbering may be covered with plaster, being attached to the joists either by means of grooves, as shown, or partially driven nails, Fig. 4. This same system of solid timbering is carried out in staircases, and other parts of a building, while for columns a series of thin planks are fastened together until the requisite section is obtained, sounder material being secured by this means, and at the same time cheaper than large scantlings. Some of the various forms of construction are shown in the illustrations. There is little doubt that, as arranged, the structure advocated by Messrs. Evans & Swain would possess a high value in resisting fire. Indeed, this has been long the experience in America, where for so many years solid timber construction has been largely employed for grain elevators, etc. The station building, at Jersey City, is built in this way of thick timber spiked or bolted together to reduce the danger of fire. The Canton grain elevator, Baltimore, also is another illustration of a similar form, with a corresponding object. Messrs. Evans & Swain may, therefore, we think, recommend this mode of construction with confidence, especially as they combine with it an additional element of safety in the heavy plastering. It need scarcely be pointed out that all timber served in this manner must be thoroughly seasoned, to prevent the joints from opening, and the continuity of the structure from being destroyed.—*Engineering.*



PLAN FOR FIREPROOF FLOORING.

MINE VENTILATOR.

WE illustrate on the preceding page a mine ventilator constructed by the *Societe des Ateliers de Construction de la Meuse*, and intended to be employed in ventilating the mines at Grisou in Belgium. The machine is composed of two horizontal steam engines, each actuating the piston of an air cylinder. The piston rods are formed in two parts connected by a crosshead. The admission of steam is regulated by two double-seated valves, actuated by a cam-shaft; the cams upon this shaft have an alternating motion given them by a simple arrangement of levers and two cataracts, the general disposition of which is shown in the drawing. The crosshead uniting the two piston rods carries a pair of wheels, which in the course of their travel bear upon moving arms, and give motion to two counterweights. The fall of these weights, regulated by the cataracts, communicate to the cam-shaft, at given periods, the motion necessary for the opening and closing of the valves, and allow to be regulated at will, the speed, the period of intermission, and the relation between the commencement of stroke of each piston. Each engine can be worked separately, although under normal conditions the movement of one controls that of the other. The travel of the piston is therefore regulated in such a way that one has traversed a given portion of the stroke before the other commences or finishes its movement.

The blowing cylinders are constructed of sheet iron, stiffened at their ends by U-irons running around them, and at the ends by suitable flanges; the necessary stiffness is imparted to them by this means. The cylinder ends are cast iron, slightly coned, this form being extremely convenient for arranging the valves, the upper half of the ends carries the outlet and the lower half the inlet valves. The former open into the air, and the latter are in communication with the shaft, being separated by a partition. The valves are of very light construction; they are made of No. 18 zinc, and hung freely from two small rings to hooks fixed in the cylinder ends. There are 48 valves at each end, of which 24 are outlet and 24 inlet. The valve seating is formed of a rubber tube covered with cloth. The largest possible area has been given to the springs; for both inlet and outlet valves at each end of the cylinder the total area is one-third the cross section of the cylinder. The pistons of the air cylinder are made so as to combine strength with extreme lightness. The form is shown in the drawings, and they are built with a cast iron centre and wrought iron radial arms covered with thin sheet iron. The piston is thus double convex, furnished around the circumference with a ring of wood in which is fixed a packing of very soft rubber. They are each carried by a system of four wheels, which run on rails attached to the lower part of the cylinder. These four wheels insure steadiness and avoid any sticking, so that the resistance of the piston is reduced to a minimum. The clear space between the piston and the cylinder ends produces only a very small loss in the efficiency of the machine. From the diagram given, it will be seen that the resistance to the outflow of air, including the lifting of the valves, does not exceed ·158 in. of water. It may be assumed that the clear space between the ends of the cylinder and the piston be 19·70 in.; this space may be called l, and the distance the pistons have to traverse in raising the pressure from ·158 in. to 7·874 in. required to ventilate the mine may be called x. Atmospheric pressure being 406·70 in., the value of x will be given by the equation—

$$\frac{x}{l}=\frac{406{\cdot}70\times{\cdot}158}{406{\cdot}70-7{\cdot}874-{\cdot}158}=\frac{406{\cdot}858}{398{\cdot}608}=1{\cdot}02$$

and the clearance plus the distance traversed will be 19·70+1·02=20·19 in., so that the lost part of the stroke will be ·39 in. only, or $\frac{1}{51}$ of the whole. In the return stroke the reverse action will take place, from the maximum pressure of 8·031 in. to ·158 in. The same condition will rule inversely, and the piston will traverse 2 per cent. of the whole stroke before opening the outlet valves. According to the diagram, if the surface b is deducted from a representing the resistance, it will be seen that the mean resistance due to the expulsion of air and lifting the valves in one stroke is less than ·039 in. of water. The following are the principal dimensions of the machine:

	In.
Diameter of steam cylinder	15·75
Stroke of piston	137·8
Diameter of air cylinder	157·5
Stroke	137·8
Volume of air per single stroke	1556 cub. ft.
Volume taken from mine per minute	42,800 to 53,000 cub. ft.
Normal pressure	7·87 in. water.

This engine, for the engraving of which we are indebted to our contemporary the *Revue Industrielle*, is shown at the Brussels Sanitary Exhibition.—*Engineering.*

WATER METERS.—A series of experiments on water meters at Wiesbaden serves to show the imperfections of those instruments. The record is the more significant as the climate to which they were exposed is not nearly so severe as our own. About one meter in every eight stuck fast in the course of the year and had to be taken out. Besides these complete stoppages, there were minor disorders which affected 8 per cent. of the rest of the lot. Four different kinds of meters were employed; each had its own vices, and one kind would not register at all with a small flow, while another kind when it got out of order checked the flow altogether.

IRON AND STEEL.

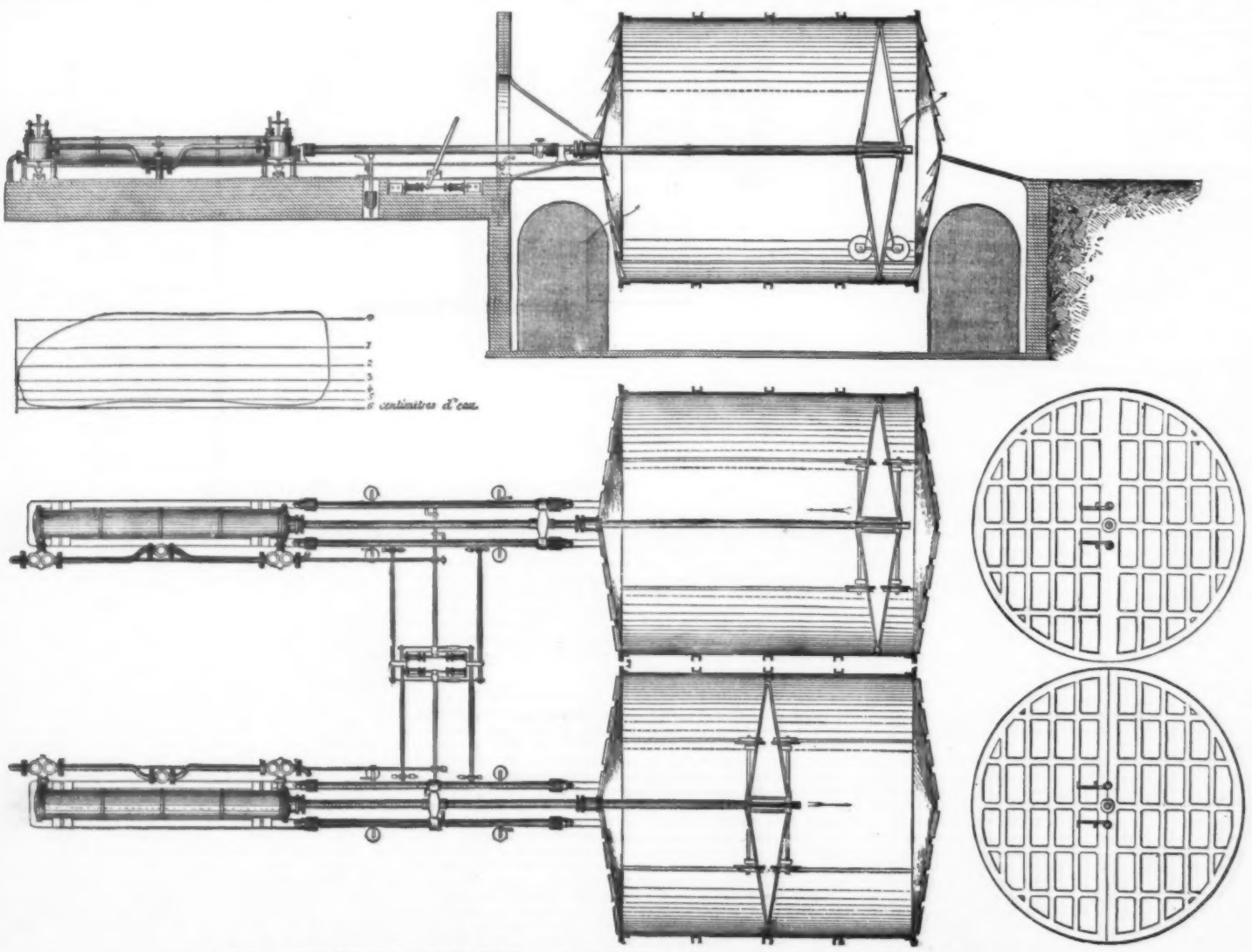
INAUGURAL ADDRESS OF DR. C. W. SIEMENS.

THE eighth annual meeting of the London Iron and Steel Institute was held, on March 20, at the Westminster Palace Hotel, London.

Dr. Siemens, the new President, delivered the following inaugural address:

The Iron and Steel Institute was called into existence in 1869 by a few of those leading members who, assisted throughout by our energetic general secretary, are still giving it their zealous and disinterested support. At their head stood His Grace the Duke of Devonshire, who, as its first President, pointed out to the young society the useful results that would be realized through a judicious combination of natural science with practical experience, and by attention to the progress in metallurgical processes effected in other countries. He thus implanted upon this Institute a vitality which has resulted in a rapid increase of its members, and a career of usefulness such as scarcely any other society for the promotion of applied science can boast of. With regard to the progress of the Institute, in the numerical strength of its membership, the number has risen from 292 in 1869 to 960 in 1876, and the proposals of candidates coming in show that the interest in the society has not abated. This numerical progress, however, cannot be expected to continue, because the Institute has now arrived at a point where it counts among its members those gentlemen who can best aid us in the objects we have in view, and it can thus afford to restrict the privilege of membership to candidates who, by their previous training and actual position, have qualified themselves to join profitably in our discussions. During last year, as the report shows, there were meetings in London and Leeds, at which numerous papers were brought before you regarding subjects of considerable interest, and which gave rise to important discussions. But, besides the reading and discussion of papers, there has been much other useful work done by the Institute; I refer to the special committees that have on various occasions been appointed by the council for the purpose of investigating questions of importance relative to the production of iron and steel; and the interest evinced in those special inquiries proves how much more may yet be accomplished by more systematic organization for the attainment of similar objects. Another branch of useful action of this Institute has been to place before its members, through its *Journal*, the latest results obtained in other countries, which work was ably performed by our late foreign secretary, Mr. David Forbes, F.R.S. The death of this distinguished gentleman must be a matter of deep regret to every member of the Institute. Out of our still young society has grown another—the British Iron Trade Association—which, under the able presidency of Mr. Geo. T. Clark, already gives promise of useful results in supplying us with reliable statistics regarding the extent and progress of the iron trade in this and other countries, and in calling the attention of our legislators to questions of tariffs, and to other measures likely to affect the interests of the British iron trade.

Educational.—Intimately connected with the interest of this institution, and with the prosperity of the iron trade, is the subject of technical education. It is not many years since practical knowledge was regarded as the one thing requisite in an iron smelter, whilst theoretical knowledge of the chemical and mechanical principles involved in the operations was viewed with considerable suspicion. The aversion to scientific reasoning upon metallurgical processes extended even to the authors who professed to enlighten us upon these subjects; and we find, in technological works of the early part of the present century, little more than eye-witness accounts of the processes pursued by the operating smelter, and no attempt to reconcile those operations with scientific facts. A great step in advance was made in this country by Dr. Percy, when, in 1864, he published his remarkable "Metallurgy of Iron and Steel." Here we find the gradual processes of iron smelting passed in review and supported by chemical analysis of the fuel, ores, and fluxing materials employed, and of the metal, slags, and cinder produced in the operations. On the continent of Europe, the researches of Ebelmann, and the technological writings of Karsten, Tunner, Grüner, Karl, Akermann, and others, have also contributed largely towards a more rational conception of the processes employed in iron smelting. It must be conceded to



THE BRUSSELS EXHIBITION.—MINE VENTILATOR AND ENGINE.

the nations of the continent of Europe that they were the first to recognize the necessity of technical education, and it has been chiefly in consequence of their increasing competition with the producers of this country that the attention of the latter has been forcibly drawn to this subject. The only special educational establishment for the metallurgist of Great Britain is the School of Mines. This institution has unquestionably already produced most excellent results in furnishing us with young metallurgists, qualified to make good careers for themselves, and to advance the practical processes of iron-making. But it is equally evident that that institution is still susceptible of great improvement, by adding to the branches of knowledge now taught at Jermyn Street, and I cannot help thinking that a step in the wrong direction has recently been made in separating geographically and administratively the instruction in pure chemistry from that in applied chemistry, geology, and mineralogy. If properly supported, the School of Mines might become one of the best and largest institutions of its kind, but it would be an error to suppose that, however successful it might be, it could be made to suffice for the requirements of the whole country. Other similar institutions will have to be opened in provincial centers, and we have an excellent example set us by the town of Manchester, which, in creating its Owen's College, has laid the foundation for a technical university, capable of imparting useful knowledge to the technologist of the future. Technical education is here spoken of in contradistinction to the purely classic and scientific education of the universities, but it must not be supposed that I would advocate any attempt at comprising in its curriculum a practical working of the processes which the student would have to direct in after-life. This has has been attempted at many of the polytechnic schools of the continent with results decidedly unfavorable to the useful career of the student. The practice taught in such establishments is devoid of the commercial element, and must of necessity be an objectionable practice engendering conceit in the mind of the student, which will stand in the way of the unbiassed application of his mind to real work. Let technical schools confine themselves to the teaching of those natural sciences which bear upon practice, but let practice itself be taught in the workshop and in the metallurgical works.

Labor.—Next in importance to an enlightened direction of metallurgical works is the obtaining of labor upon reasonable terms. The wages paid in this country are, as a rule, higher than those prevailing on the continent of Europe, and I do not belong to those who would wish to see them materially reduced. The late Mr. Brassey found as the result of his experience that the cost of labor, that is, the co-efficient resulting from the division of the work done per day, by the day's wage, was a constant quantity for all countries. This rule would lead to the conclusion that the more costly but effective labor, as measured by a day's wage, must be the cheaper in the end, because it produces a greater result with a given amount of plant. I have no reason to doubt the general truth of this proposition, provided only that it is not disturbed by misconceptions, regarding the supposed antagonism between labor and the capital and skill directing it which misconceptions have exercised a baneful influence upon the industries of this and other countries in recent times. Both employer and employed have reason to reflect seriously upon the experience gained during the late period of high prices. Whilst empioyers added largely to their producing plant, and acquired additional colliery and mining property in order to increase their output, and so took advantage, unwisely I think, of a temporary inflation, it can hardly be considered a matter for surprise that the working classes caught up the feverish excitement, and endeavored to obtain their share of the golden fruits that were supposed to accrue to their employers. Scarcity of labor was naturally suggestive of combination, and high rates of wages supplied the means of imposing onerous conditions upon the employer, whereby the development of economical processes was effectually retarded. The commercial crisis which ensued has rendered the depression more general and more sweeping than could have been reasonably expected, and now that we find ourselves at what we hope may be regarded as the extreme ebb of the ever-fluctuating tide of prosperity, it behoves us to consider carefully how a recurrence of the same causes of mischief may in the future be rendered less dangerous in their results. One of the most available methods of attaining this important result would be in establishing the relations between employers and employed upon the basis of mutual interest. I hold that capital has its duties to perform as well as its rights to maintain, and that whilst the minimum of wages is that which enables the workman to live with reasonable comfort, both parties would be materially benefited by so arranging wages as to make them payable in great measure upon results, both as regards quality and quantity of work produced, whilst by the establishment of mechanics' institutes, reading-rooms, and mutual benefit associations, in connection with individual works, the feeling of community of interest would be further strengthened, and a recurrence of antagonistic action, so destructive to commercial results, would be avoided.

Fuel.—Next in importance to cheap, or rather to efficacious, labor in the production of iron and steel comes cheap fuel—a subject to which, as you are aware, I have devoted considerable attention, and I would, therefore, treat it, with your permission, rather more fully than other subjects of perhaps equal importance. Fuel, in the widest acceptation of the word, may be said to comprise all potential force which we may call into requisition for effecting our purposes of heating and working the materials with which we have to deal, although in a more restricted sense it comprises only those carbonaceous matters which in their combustion, yield the heat necessary for working our furnaces, and for raising steam in our boilers. It may safely be asserted that the great supply of energy available for our purposes has been, or is being, derived from that great orb which vivifies all nature—the sun. In the case of coal, it has been shown that its existence is attributable to the rays of the sun, which in former ages broke up or dissociated carbonic acid and water in the leaves of plants, and rendered the carbon and hydrogen, thus separated from the oxygen, available for re-combustion. The same action still continues in the formation of wood, peat, and, indeed, all vegetable matter. The solar ray produces, however, other forms of energy through the evaporation of sea-water, and the resulting rainfall upon elevated lands, and through currents set up in the atmosphere and in the sea, which give rise to available sources of power of vast aggregate amount, and which may also be regarded in the light of fuel in the wider sense. The form of fuel which possesses the greatest interest for us—the iron smelters of Great Britain of the nineteenth century—is without doubt the accumulation of the solar energy of former ages, which is embodied in the form of coal, and it behoves us to inquire what are the stores of this most convenient form of fuel. Recent inquiry into the distribution of coal in this and other countries has proved that the stores of these invaluable deposits are greater than had at one time been supposed. I have compiled a table of the coal areas and production of the globe, the figures in which are collected from various sources. It is far from being complete, but will serve us for purposes of comparison:

The Coal Areas and Annual Coal Production of the Globe.

	Area in square miles.	Production in 1874. Tons.
Great Britain	11,900	125,070,000
Germany	1,800	46,658,000
United States	192,000	50,000,000
France	1,800	17,060,000
Belgium	900	14,670,000
Austria	1,800	12,280,000
Russia	11,000	1,392,000
Nova Scotia	18,000	1,052,000
Spain	3,000	580,000
Other countries	28,000	5,000,000
	270,200	274,262,000

This table shows that, roughly, the total area of the discovered coal fields of the world amounts to 270,000 square miles. It also appears that the total coal deposits of Great Britain compare favorably with those of other European countries; but that both in the United States and in British North America, there exist deposits of extraordinary magnitude, which seem to promise a great future for the New World. According to the report of the Coal Commissioners, published in 1871, there were then 90,207 million tons of coal available in Great Britain, at depths not greater than 4,000 feet, and in seams not less than 1 foot thick, besides a quantity of concealed coal estimated at 56,273 millions of tons, making a total of 146,480 millions. Since that period there have been raised 600 millions of tons up to the close of 1875, leaving 145,880 millions of tons, which, at the present rate of consumption of nearly 132 millions of tons annually, would last 1,100 years.

Statistics show that during the last twenty years there has been a mean annual increase in output of about 3½ millions of tons, and a calculation made at this rate of increase would give 250 years as the life of our coal fields. In comparing, however, the above rate of increase with that of population and manufactures, it will be found that the additional coal consumption has not nearly kept pace with the increased demand for the effects of heat, the difference being ascribable to the introduction of economical processes in the application of fuel. In the case of the production of power, the economy effected within the last twenty years exceeds 50 per cent., and a still greater saving has probably been realized in the production of iron and steel within the same period, as may be gathered from the fact that a ton of steel rails can now be produced from the ore with an expenditure not exceeding 50 cwt. of raw coal, whereas a ton of iron rails, twenty years ago, involved an expenditure exceeding 100 cwt. According to Dr. Percy, one large works consumed, in 1859, from five to six tons of coal per ton of rails. Statistics are unfortunately wanting to guide us respecting these important questions. Considering the large margin for further improvement regarding almost every application of fuel which can be shown upon theoretical grounds to exist, it seems not unreasonable to conclude that the ratio of increase of population and of output of manufactured goods will be nearly balanced, for many years to come, by the further introduction of economical processes, and that our annual production of coal will remain substantially the same within that period, which, under those circumstances, will probably be a period of comparatively cheap coal. The above-mentioned speculation leads to the further conclusion that our coal supply at a workable depth will last for a period far exceeding the shorter estimated period of 250 years, especially if we take into account the probability of fresh discoveries, of which we have had recent instances, particularly in North Staffordshire, where a large area of coal and blackband ironstone is being opened up, under the auspices of His Grace the Duke of Sutherland, by our member, Mr. Homer. Wherever coal fields are found in Great Britain, they exist, generally speaking, under favorable circumstances. The deposits are for the most part met with at reasonable depths, the quality of the coal is unsurpassed by that of other countries, and although the coal and ironstone do not occur together in all the iron-producing districts, the distance from the coal to the iron is small, compared with that met with in other countries, and the insular position of Great Britain renders water carriage, both for internal communication and for the purpose of export, more readily available than elsewhere. These advantages ought to decide the present contest for cheapness in supplying the markets of the world with iron and steel in favor of this country.

Coal assumes, in many instances, the form of anthracite, and although the South Wales district contains large deposits of this mineral fuel, comparatively little use has been hitherto made of it for smelting purposes. When raw anthracite is used in the blast furnace mixed with coke, it has been found that the amount so used should be limited to from 10 to 15 per cent., or the furnace is apt to become choked by an accumulation of decrepitated anthracite.

Coke.—At Creusot, in France, this difficulty was overcome many years ago by crushing the anthracite coal, mixing it intimately with crushed binding coal, and coking the mixture of about equal proportions in Appold's vertical coke ovens. The result is a somewhat unsightly but exceedingly hard and efficacious coke. A similar method has been followed for some time in South Wales, where coke is now produced, containing as much as 60 per cent. of anthracite, bound together by 35 per cent. of binding coal, and a further admixture of 5 per cent. of pitch or bitumen, the whole of the materials being broken up and intimately mixed in a Carr's disintegrator prior to being coked in the usual manner. Coke of this description possesses great power of endurance in the furnace, and is worthy the attention of iron smelters

American Fuels.—In the United States of America anthracite plays a most important part, being, in fact, the only mineral fuel in the Northern States east of the Alleghany mountains. Its universal application for blast furnaces, for heating purposes, and for domestic use, imparts to the eastern cities of the United States a peculiar air of brightness, owing to the entire absence of smoke, which must impress every visitor most agreeably, and the difference of effect produced by the general use of this fuel, as contrasted with that of bituminous coal, is most strikingly revealed in a short day's journey from Philadelphia, the capital of the anthracite region, to Pittsburgh, the center of application of bituminous coal. In visiting lately the deposits of anthracite coal of the Schuylkill district, I was much struck with their vastness, and with the manner and appliances adopted for working the same. The American anthracite is less decrepitating than ours, but its successful application to its various purposes is the result chiefly of the judicious manner in which it is prepared for the market. The raw anthracite as it comes from the mine is raised to the top of a wooden erection some 80 feet or 90 feet high, in descending through which it is subjected to a series of operations of crushing, washing, sieving, and separating of slaty admixtures, after which it is delivered through separate channels into railway wagons, as large coal, egg coal, walnut coal, and pea coal, each kind being nicely rounded and uniform in size. The dust coal, which amounts to nearly one-half of the actual quantity raised, is allowed at present to accumulate near the mine, but experiments are now being carried out to utilize this also for steam boiler purposes.

Peat.—Next in importance to mineral fuel, properly speaking, are lignite and peat, of which vast deposits are met with in most countries. These may be looked upon as coal still in course of formation, and the chief drawback to their use, as compared with that of real coal, consists in the large percentage of water which they contain, rendering them inapplicable in their crude condition to the attainment of high degrees of heat. These difficulties may be overcome by subjecting the wet material to processes of compression, desiccation, and coking, whereby excellent fuel and products of distillation have been obtained, although the cost of their production has hitherto exceeded their market value. Crude air-dried peat has, however, been rendered applicable for obtaining high degrees of heat such as are required for metallurgical operations by means of the regenerative gas furnace; and it is important to observe that the calorific value of a ton of air-dried peat or lignite, if used in this manner, is equal to that of a ton of good coal if deduction is made in both cases of the percentage of moisture and earthy matter. The carbonaceous constituents of peat yield, indeed, a very rich gas suitable for melting steel for re-heating iron, and the only precaution necessary is to pass the gas from the producer over a sufficient amount of cooling surface to condense the aqueous vapor it contains, before its arrival at the furnace. This precaution is not necessary, however, in dealing with some of the older lignites, such as occur abundantly in Austria and Hungary, and which may be ranked as almost equal in value with real coal, except for blast furnace purposes.

Natural Gas Fuel.—Fuel also occurs naturally in the gaseous condition, a fact but too well known to every practical coal miner. Occasionally, however, it is found separated from the coal with which it may have been primarily associated, and in those cases it has been made practically available as fuel. At Baku, on the Caspian Sea, natural gas has issued spontaneously from the ground for centuries past, and the column of perpetual fire thus produced has served the purpose of giving the Parsees a holy shrine at which to worship their deity. In the district of Pennsylvania, a more substantial application has been made of the gas issuing from many of the borings, in providing fuel for working pumping machinery and in lighting the district. The quantity of gas issuing from some of these wells may be judged from the fact that one of them, after discharging for three years as much gas as could escape into the atmosphere under a pressure estimated at not less than 200 lbs. on the square inch, has lately been connected by means of a 5 in. pipe with Pittsburgh—a distance of eighteen miles—where seventy puddling and re-heating furnaces are worked entirely by the fuel so supplied. But even this result furnishes only an imperfect idea of the calorific power represented by this single issue of natural gas, inasmuch as the combustion is carried on in these furnaces on the most wasteful plan, the gas being mixed imperfectly with cold air, and converted to a large extent into dense masses of smoke. An analysis of this gives:

Hydrogen	10·50
Marsh gas	80·11
Ethylene	5·72
Carbonic acid	0·66

Artificial Gas Fuel.—Although the use of natural gas is not likely to assume very large proportions owing to its rare occurrence, its application at Pittsburgh has forcibly reminded me of a project I had occasion to put forward a good many years ago, namely, to erect gas producers at the bottom of coal mines, and, by the conversion of solid into gaseous fuel, to save entirely the labor of raising and carrying the latter to its destination. The gaseous fuel, in ascending from the bottom of the mine to the bank, would acquire in its ascent, owing to its temperature and low specific gravity, an onward pressure sufficient to propel it through pipes or culverts to a considerable distance, and it would be possible in this way to supply townships with heating gas, not only for use in factories, but, to a great extent, for domestic purposes also. In 1869, a company, in which I took a leading interest, was formed at Birmingham, under the sanction of the Town Council, to supply the town of Birmingham with heating gas at the rate of 6d. per 1,000 cubic feet, but their object was defeated by the existing gas companies, who opposed their bill in Parliament, upon the ground that it would interfere with vested interests. I am still satisfied, however, that such a plan could be carried out with great advantage to the public; and although I am no longer specifically interested in the matter, I would gladly lend my aid to those who might be willing to realize the same.

Liquid Fuel.—Fuel also occurs naturally in the liquid state, and if mineral oils could be obtained in quantities at all comparable to those of solid fuel, liquid fuel would possess the advantages of great purity and high calorific value; but, considering its rare occurrence and comparatively high price even in the oil districts of Pennsylvania and Canada, its use, as a fuel for smelting purposes, need not be here considered.

Solar Fuel.—According to the general definition of fuel given above, we have to include the evaporative effect of the sun's rays, by which sea water is raised to elevated mountain levels, whence it descends towards the sea, and in so doing is capable of imparting motion to machinery. This form of fuel, which takes the place of the coal otherwise expended in raising steam, has been resorted to in all countries since the dawn of civilization, and it is owing to this circumstance that the industries of the world were formerly very much scattered over the valleys and gorges of mountainous districts, where the mountain stream gave motion to the saw mill or flour mill, to the trompe of the iron smelter, and to the helve of the iron and steel manufacturer.

The introduction of the steam engine, towards the end of the last century, changed the industrial aspect of the world in causing manufactories to be massed together in great centers, and this tendency has been still further augmented in consequence of the construction of canals and railways, which enable us to bring together the raw material, and to disperse the manufactured product at a comparatively low cost. It is not unreasonable, however, to expect that a certain reaction in this process of centralization will gradually take place,

because, in consequence of ever-increasing competition, the advantage of utilizing natural forces, which we could afford to neglect during a period of general prosperity, becomes again an essential element in determining the very lowest price at which our produce may be sent into the market.

Water-Power.—The advantage of utilizing water-power applies, however, chiefly to continental countries with large elevated plateaus, such as Sweden and the United States of North America, and it is interesting to contemplate the magnitude of power which is now for the most part lost, but which may be, sooner or later, called into requisition. Take the Falls of Niagara as an example. The amount of water passing over these Falls has been estimated at 100 millions of tons per hour, and its perpendicular descent may be taken at 150 feet, without counting the Rapids, which represent a further fall of 150 feet, making a total of 300 feet between lake and lake. But the force represented by the principal Fall alone amounts to 16,800,000 horse-power, an amount which, if it had to be produced by steam, would necessitate an expenditure of not less than 266,000,000 tons of coal per annum, taking the consumption of coal at 4 lbs. per horse-power per hour. In other words, all the coal raised throughout the world would barely suffice to produce the amount of power that continually runs to waste at this one great Fall. It would not be difficult, indeed, to realize a large proportion of the power so wasted, by means of turbines and water-wheels erected on the shores of the deep river below the Falls, supplying them from canals cut along the edges But it would be impossible to utilize the power on the spot, the district being devoid of mineral wealth, or other natural inducements for the establishment of factories. In order practically to render available the force of falling water at this and the thousands of other places under analogous conditions, we must devise a practicable means of carrying the power to a distance.

Carrying Power Over Long Distances.—Sir William Armstrong has taught us how to carry and utilize water-power at a distance, if conveyed through high pressure mains, and at Schaffhausen, in Switzerland, as well as at some other places on the continent, it is conveyed by means of quick-working steel ropes passing over large pulleys. By these means, power may be carried to a distance of one or two miles without difficulty.

Transmitting Power by Electricity.—Time will probably reveal to us effectual means of carrying power to great distances, but I cannot refrain from alluding to one which is, in my opinion, worthy of consideration, namely, the electrical conductor. Suppose water-power to be employed to give motion to a dynamo-electrical machine, a very powerful electrical current is the result. This may be carried to a great distance, through a large metallic conductor, and there be made to impart motion to electro-magnetic engines to ignite the carbon points of electric lamps, or to effect the separation of metals from their combinations. A copper rod of 3 in. in diameter would be capable of transmitting 1,000 horse power a distance of, say, thirty miles, an amount sufficient to supply one quarter of a million candle power, which would suffice to illuminate a moderately sized town. The use of electrical power has sometimes been suggested as a substitute for steam power; but it should be borne in mind that so long as the electric power depends upon a galvanic battery it must be much more costly than steam power, inasmuch as the combustible consumed in the battery is zinc, a substance necessarily much more expensive than coal. But this question assumes a totally different aspect if in the production of the electric current a natural force is used, which could not otherwise be rendered available.

Wind-Power.—The force of the wind is another source of natural power, representing fuel according to the general definition above given, which, though large in its aggregate amount, is seldom used, owing to its proverbial uncertainty.

On this account we may dismiss it from serious consideration until our stores of mineral wealth are wellnigh exhausted, by which time our descendants may have discovered means of collecting, storing, and utilizing such a power in a manner entirely beyond our present conceptions.

(To be continued.)

SOLID STEEL CASTINGS.

MR. F. GAUTIER, of Paris, in a recent paper on this subject before the Iron and Steel Institute, said that when steel is cast in an iron ingot mould, or mould of any kind, cavities of a more or less rounded shape are usually seen inside, apparently caused by gas escaping from the mass. Mr. Henry Bessemer, the first among the metallurgists, has demonstrated that these blow-holes were filled with oxide of carbon, and this view has since been entirely confirmed. When these blow-holes are altogether inside, and do not burst through the crust, they remain silvery white; it is a simple solution of continuity, and to get rid of them it is sufficient to weld the metallic parts by re-heating and the use of a hammer or rolls. What becomes of the carbonic oxide? It is re-incorporated with the metal. This has not been determined yet. But the fact is that when rolled steeled bars, drawn from honeycombed ingots, are broken, no trace is found of this kind of defect. When the blow-holes communicate with the outside, and the sides of the ingots are pierced with small holes, well known to the steel manufacturers, the color is no longer a silvery white; they assume more or less the colors of the rainbow, and even become black. Hammering and rolling do not entirely eliminate these blow-holes, as a perfect welding of the metallic particles is prevented by the presence of oxide of iron. There remain some black streaks, which sometimes penetrate to a depth of 1-10th inch (3 millim). In order to correct these surface defects, the welding must be done by allowing the piece to undergo heating at as high a temperature as possible; the steel is then covered with sand, and hammered vigorously. The oxide of iron which prevented welding is combined with silica, and forms a silicate which pressure easily expels. This is a general practice in the manufacture of fine steels. It will be seen that it is an easy matter to remove blow-holes when the steel has to undergo mechanical eleboration; but it is not so with castings. Generally, the more steel is carbonized the better it will flow while casting, and fewer blow-holes will form. On the contrary, the more a steel is decarbonized the less fluid it will be, and more blow-holes will form. It is probable that hard steel keeps better the oxide of carbon in dissolution: or else it escapes more freely on account of the greater fluidity of the metal.

The Germans have long manufactured steel without blow-holes. Every one will remember those splendid ingots, clean fractured, growing in weight at each successive exhibition, first beginning with two tons, and finally reaching forty-five. The Krupp ingots, the cast wheels and bells of Bochum, certainly astonished the metallurgical world for some time. The process of manufacture was kept a most profound secret, and has not yet been published. More than six years ago the Terre Noire Steel Works found out, by reasoning rather than practice, the process of the German works, and the improvements they have made have radically transformed the result. It seems well proven now that the German products, without blow-holes, are obtained by an addition of a very siliceous pig just before casting; and thus they are found to be highly carburized, and the chemical analysis shows a rather considerable portion of silicon. To find an explanation of the result, we must go back to the theory of the Bessemer process. It is well known that the combustion of the silicon takes place during the first part of the operation; there is no flame, or rather, there is a series of brilliant sparks; the yellow sodium band, characteristic of all flames, is not seen; no oxide of carbon is formed while there remains any silicon to be oxidized; the silicon decomposes the oxide of carbon, or, which is the same, prevents it from forming; therefore, if blow-holes are filled with oxide of carbon, they will be made to disappear by the addition of silicon. The carbon is deposited and dissolved in the steel, and the silica is formed. Experience shows that steels treated in this manner are generally without blow-holes.

At the Terre Noire Steel Works the manufacture of steel without blow-holes has been perfected by using a silicide of manganese and iron, which gives to the product remarkable qualities. The silicon prevents blow-holes by decomposing the oxide of carbon, which is in dissolution, and tends to escape during solidification. The manganese reduces the oxide of iron, and prevents a further production of gases by the reaction of the oxide on the carbon. We have seen above that, in the decomposition of oxide of carbon by silicon, silica was produced, and afterwards a silicate of iron, which remained interposed within the steel. The manganese allows the formation of silicate of iron and manganese, which is much more fusible, and passes into the slag. For this reason the metal is not altered by a foreign body, and this is a capital point. In order to show plainly the complete structural difference between steels without blow-holes obtained with silicon alone, and those obtained with an alloy of silicon and manganese, Mr. Pourcel places two receptacles, one holding steel by silicon alone, and the other steel by an alloy of silicon and manganese in a porcelain tube. A current of chlorine is passed until all the iron is removed in a state of chloride. It is seen, then, that in the first receptacle there remains a network of silicate of iron preserving the original form of the pieces, while the steel by alloy leaves no residuum.

As a general rule, all metals possessing a crystalline texture are brittle, as, for instance, antimony, bismuth, and zinc in ingots: while a confused and irregular texture corresponds to the greatest resistance. Steel is not an exception to this rule, and if a fracture is crystalline the piece is very brittle. Fortunately, this defect can be modified in several ways: 1. By simple re-heating to cherry red, when an ingot with coarse fracture, and completely lacking the requisite strength, will suddenly be transformed after ordinary cooling into a fine-grained and strong product; 2. By hammering, at a sufficiently high temperature, cast steel loses its crystalline structure, provided this hammering is continued while cooling takes place down to a certain point, varying with the different steels, and beyond which the metal preserves its whole power of resistance. If hammering was left off at a high temperature, and the metal abandoned to itself, the crystalline structure would re-appear, and with it the lack of strength; 3. The rapid cooling of a cast metal also destroys the crystalline state; this was observed in wrought iron armor places. Steel, then, seems to behave like an exceedingly concentrated dissolution of a salt easily crystallizable, the crystallization of which is prevented by certain precautions only.

In spite of the seeming boldness in substituting cast for forged steel, in spite of the little faith of the ordnance men themselves, at this moment the steel works at Terre Noire manufacture regularly 9½ in. projectiles, capable of penetrating at an angle of 30° plates 8 in. thick, with the relatively slow speed of 1,400 ft. per second. The projectiles never break—sometimes the point is slightly bent. It is not known yet whether it will be possible to begin immediately the manufacture of cannons in one piece, as was formerly done in cast iron cannons for the navy and the defence of towns. But there is one idea which presented itself naturally, and which is being studied even now—it is nothing less than the replacing the cast iron body by a cast steel one in coiled guns. Thus, a metal hardly able to stand an effort equal to 10 tons will be replaced by another requiring 33 tons, at least, to break it, supposing, for security's sake, that the softest metal was used. As to the different industrial applications of the new metal, they naturally present themselves to every mind, and we might even say they will push themselves forward, bearing with them these two great advantages—solidity and economy.

Mr. Henry Bessemer wished to say a few words on Mr. Gautier's paper. In the exhibition of 1862 he exhibited a number of castings in steel, including a 17 cwt. ingot, to show that cast steel could be produced with no air bubbles. It was produced by the use of iron and manganese. He ascertained in his works at Sheffield that when the best Swedish iron was put into the crucible, and left only a sufficient time to fuse, it was bubbly and brittle, but when left in for an hour it became well melted. He at once sought the chemical difference, and ascertained by six or seven samples of good and bad that the well melted always contained some silicon. Seeking the source of the silicon, he found that the plug-hole in the crucible used for facilitating shaping was stopped with sand, so of the silicon, in which, when the metal remained long in the pot combined with the steel. He found, too, the Tow Law Iron Works could give them a semi spiegeleisen, with 3 or 4 per cent. of silicon and about 7 per cent. of manganese, and by the use of this alloy they got sound ingots. He would take the opportunity of mentioning that Schneider, of Creusot, sent over his manager, who passed a month at their works at Sheffield, and he (Mr. Bessemer) supplied that firm with twenty-two sheets of drawings. Mr. Schneider, Jr., was also at their works, and he might tell them that, in order that they should not commence a work without security of results, they gave both the manager and Mr. Schneider, Jr., every information in their power. They were thoroughly satisfied that they could make good iron by the process, and the erection of the machinery was at one time commenced, but such delay was used in its completion that it was only ready six weeks before his first patent expired, and they refused to pay him a farthing. As he had said this with regard to Creusot and its proprietors, in speaking of the present proprietors he should mention that Mr. Gautier was not connected with the Creusot but with the Terre Noire Works.

Mr. Riley said that he had made at Messrs. Kitson's works silicide of iron up to 33 per cent. of silicon; and he might mention that in Mushet's titanium steel he could find no titanium, but there was 1½ per cent of silicon. With an iron with 2 per cent of silicon so hard a tool was made that he turned off a chilled steel rail. As to the relation between silicon and carbon, he had found invariably that as the silicon went up even to beyond 20 per cent. the carbon went down.

Mr. Gautier stated that their alloy of silicide of manganese was made in a blast furnace.

Mr. Riley thought there was no doubt that if they had too large a quantity of fuel in the furnace and thus burnt out the carbon they could get a siliceous iron.

Mr. A. L. Holley (of America) said that he had had the opportunity of examining the steel at Terre Noire. It was in America a matter of great importance to produce castings instead of forgings, and he, therefore tried to see whether steel without blow-holes could be regularly produced. He believed that there were many iron and steel processes which had completely failed because the exact conditions of success were not thoroughly understood. He found that in the Terre Noire process a great degree of accuracy was necessary both as to what should go into the bath and as to the precise time at which it should go in. The Terre Noire Company allowed him to examine everything most minutely. He found the conditions of success to be that the oxygen must be preserved in the metal, and that the carbon must be kept out to the greatest degree. Some carbon was introduced in the ferro manganese and ferro silicon. The bath was made entirely of spiegeleisen, and care was taken to keep plenty of manganese in stock, and to remove the oxide of iron that is formed. The color of the slag was a delicate test of the percentage of manganese in the steel. Careful observations of the black and olive green lines would at once determine whether damaging oxidation were going on in the bath. But towards the end of the operation the carbon and manganese must be pretty well burnt out. The slag color test he regarded as almost conclusive. A little ingot of 1½ inch square, flattened into a disk, which was examined for cracks at the periphery, showed the condition of the metal. The color of the slag, the softness of the steel, and the fluidity of the steel had to be taken into consideration, and the soundness of the castings to be made could thus be accurately determined. The three conditions, however, must be obtained simultaneously. He formed the conclusion that the means of discovering the defects were very simple, and that the remedies were complete, and much more numerous than the defects. With ordinary skill it was perfectly easy for the operator to make the solid steel with as much certainty as ordinary steel. To show that the process was well in hand, he need only say that the Terre Noire Company had been making the steel for some years. During the three weeks he was at Terre Noire only two charges got out of control, one of these being because the roof of the furnace fell in. He considered that to the Terre Noire Company was due the credit of having developed a substantially new process. Many sound steel castings have been made at Terre Noire by Messrs. Euverte & Poucell as the result of the experiments which they had been some years carrying on; and, although the broad principle might have been long known, they had arrived at an entirely new process as to the times and seasons at which the several steps in it were performed. He believed it would prove to be one of the most important open air processes ever discovered.

Mr G. J. Snelus considered the thanks of the Institute due both to Mr. Gautier and Mr. Holley, and remarked that he believed soft steel with ferro-manganese would replace copper, and experiments which he had made confirmed that view. They all now knew that burnt iron means siliceous iron, and he believed that they would get a compound of iron, manganese, and silicon for a cheap product to be used instead of forgings. If the silicon were in the steel without carbon the steel would be tough, and bear a high strain, and they always found the manganiferous metal to be a soft metal, and the siliceous metal a good casting metal. He thought they could not give to the Terre Noire Company too much credit for what they had done.

Mr. Stead generally confirmed Mr. Riley's views as to the estimation of manganese.

Mr. Snelus suggested that the Terre Noire process could be as well carried out by the Bessemer as by the Terre Noire process.

Mr. Bessemer would mention that the samples shown at the Exhibition of 1862 were not mere specimens, and that since that date they had continued and very much increased the making of these castings. They had at present many cast steel cranks running under locomotives which had never been touched with a hammer, and they found that a ¼-inch slab taken out would bend together on itself without showing defects.

Mr. Hadfield has also a three-double throw-crank at work which has never had a hammer on it.

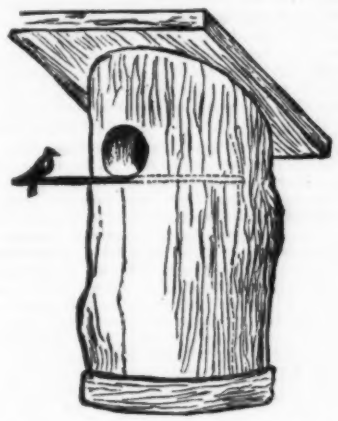
Mr. D. Adamson considered that as contraction in cooling could not be avoided, the contraction of a 12-inch tube being equal to an ¼ in. in the diameter, much advantage was derivable from Whitworth's system of compression, which was successfully carried on in Manchester, if it could not succeed in France. He agreed that soft steel could replace copper, for he had never seen copper undergo the punishment of beating a dome 2 ft. diameter and 2 ft. high out of a solid sheet, and with wooden mallets, so well as soft steel. With copper such a feat was only possible with frequent re-annealings with the utmost care.

SIZE OF HYDROGEN ATOMS.

ANNAHEIM has described a simple lecture experiment in which the coloring power of fuchsin and cyanin is made use of to illustrate the extraordinary divisibility of matter. To form an idea of the amount of coloring matter visible to the naked eye, he weighed out 0·0007 gram fuchsin ($C_{20}H_{19}N_2HCl$)—a fragment about half a millimeter in diameter—dissolved it in alcohol and diluted the solution to a liter. In each centimeter, therefore, there was contained 0·0000007 gram coloring matter; and yet, placed in a burette one centimeter in diameter, the colored showed distinctly even from a distance. A single drop of this solution—of 35 to the cubic centimeter—in a test-tube placed on white paper showed a distinct red color. Hence it follows that the eye can perceive ·00000002 gram fuchsin. But if we assume that each drop contains only one molecule, and it cannot contain less, then, since the molecular weight of fuchsin is 337·5, the maximum weight of a hydrogen atom is $\frac{1}{337 \cdot 5}$ of 0·0000002 gram, or 0·000000000059 gram! The same experiment with cyanin ($C_{25}H_{15}N_2I$) whose molecular weight is 526, leads to a similar result. One milligram, dissolved in a liter of alcohol, will give for each drop 0·0000000285 gram. From this, it appears that the weight of the hydrogen atom cannot exceed 0·000000000054 gram, a curiously close coincidence.—*Ber. Berl. Chem. Ges.*

BIRDS IN GARDENS.

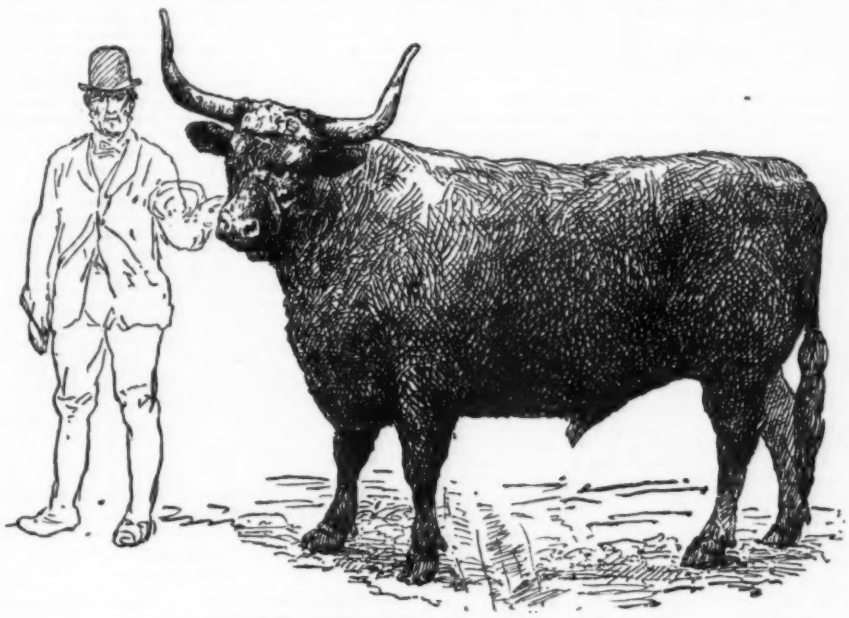
IN Christiania and its neighborhood, and doubtless in other parts of Norway, the gardeners and proprietors fasten (with wire or nails), "Ruge Kasser," or "hatching-boxes," to the upper parts of the trees in their gardens and grounds. These are regularly resorted to by such birds as build their nests in the holes in trees (which are not frequently to be



found in the young, healthy, growing trees in a garden or plantation near a house), and broods are hatched and reared, safe from the depredations of *Felis domestica*. The presence of birds in our gardens must be looked upon as an advantage, as they generally feed upon insects. The dimensions are:—Height at back, 16 in.; and at the front, 11 in. Diameter, outside measure, 8 in.; inside measure, 5 in. Length of sloping roof, 13 in.

SUSSEX CATTLE.

OUR engraving illustrates the general characteristics of the Sussex breed, which finds much favor with English farmers.



PRIZE SUSSEX OX—ISLINGTON.

The engraving is from the *Agricultural Gazette*, and represents the prize Sussex steer "Islington," belonging to Captain Taylor, which was exhibited at the recent Smithfield Club Show.

PRESERVATION OF FODDER.

PROFESSOR CALDWELL lately gave a full description of the new method for preserving corn fodder, now becoming extensively adopted in southern France and some other parts of Europe, known as *ensilage*, or burying in trenches. This mode of packing green fodder in pits or trenches, requires that it may be made as solid as possible, and then covered with earth. It undergoes a fermentation, is softened in texture so that the hard stalks become capable of being easily eaten; and, in fact, the process is not unlike that by which sour krout is made. It is absolutely essential that the ground selected for the trenches has a perfect drainage, as water

would spoil the result. The covering with compact earth should be a foot and a half to two feet thick, and packed solid to exclude air. The usual mode is to dig trenches two or three feet deep; but if there is any fear that the subsoil will be wet, the fodder is placed on the surface, and covered somewhat like a potato heap, but is oblong instead of circular. The figure is a cross section of such a heap, showing the chopped fodder within, and the earth covering over it. If well secured, this sour krout fodder will continue uninjured for months, or even for a year. The fodder is cut rather short, so as to favor solid packing, and mixed with a portion of straw. The heaps may be made six feet high, and fifteen feet more or less in length, according to the quantity to be preserved. Straw is then placed over the heap and the earth added. This, if properly spaded up, will leave a trench all around the heap, to facilitate drainage. Trenches are better, in that they require less labor to cover. A section of one

of these is here shown and may be two and a half to three feet below the surface, six to eight feet wide, and about the same in entire height. Some persons use no straw, in which case it is necessary that the fodder be allowed to become partly dried. Others do not cut the fodder short, but in this case it is more difficult to tread it down compactly. Some add salt. It is important in any case to press or tread the fodder as compactly as possible without any interstices or air-spaces.

The total cost of the entire operation is reported not to exceed twenty-four to thirty cents per ton; or, including fodder and all, with one-fifth straw, $3.20 per ton, except covering.

Fermentation always sets in; it could not be otherwise; but this is kept within bounds by the moderate bulk of the heaps, its coolness by contact with earth, and by the entire exclusion of external air. The changes that take place, which Professor C. mentioned in detail, are that the fodder becomes more digestible and slightly acrid, and, if cattle dislike it at first, they soon learn to eat it greedily. If fed at the rate of 20 lbs. to 1,000 lbs. of live weight of animal, it does not affect the flavor of milk in the least; 40 lbs. of *ensilage* fodder and 10 lbs. of meal are good feed for such an animal for a day, and 50 lbs. have been given without any harm. The practice is especially recommended for adoption in this country, where corn fodder is more easily raised than roots.

When used, an opening is made at one end of the heap, and it is gradually used, working towards the other end. It spoils in a day or two when exposed to the air, and for this reason no more should be shoveled out than is needed for a feeding, when the hole should be covered with a thick layer of straw trodden down.

In the discussion which followed, inquiry was made if this process could not be imitated by packing green hay in tight barns. In answer, a case was mentioned where this was attempted, and resulted in the destruction of the barn and its contents by spontaneous combustion. Professor Caldwell cautioned against the attempt, inasmuch as there could not be exclusion from air, the fodder was not kept cool by proximity to the earth, and the mass would be too large for safety.

CORN STOVER AND HAY.

IT will be remembered by some, that on Waushakum Farm, the corn stover is estimated to be worth $8 a ton. Many persons come to the barn, and if the pigeons overhear and make record of the conversation, they must note a wide diversity of opinion as to the comparative value of fodder and hay, and we doubt not, think very poorly of the business capacity of farming mankind for permitting a question of this importance to remain in dispute. It is a practical question, and admits of a practical answer. Like many other questions of the farm, each person thinks out a conclusion for himself, as whether it will pay him to do so and so, and does not bring the question to the proof of experiment, so as to give answer in precise terms, because to do so is both costly in time and money.

Can any one doubt that, were any one of our agricultural societies securing the $600 annual bounty from the State, in a condition to divert this bounty for one year from the purpose of exhibition merely to the answering of this question: What is the worth on the dairy farm of a ton of well cured corn stover, under various circumstances, when the well cured English hay is worth $20 a ton?—can any one doubt that the answer would be worth the price to the people of the State?

Some good farmers express the opinion that what the cows eat of the stover will produce as much milk as hay. Our own experience would seem to render this opinion, under some given circumstances, probably correct; our own experience permits us to state that but from 10 to 15 per cent. of well cured stover is refused by our herd of Ayrshires. If we assume the higher estimate, then, from a ton of the stover, the cattle consume some 1,700 pounds: leaving of the ton, to be cut up for bedding of calves, 300 pounds. If we permit a larger waste, which sometimes may be profitable, and only ask the cows to consume 1,500 pounds of the ton placed before them, it would appear that farmers willing to pay $20 a ton for hay should be willing to pay at least $15 a ton for the stover. In this case the portion of the ton of fodder eaten by the cows is bought at a cent a pound, which is the same price as is paid for the hay. This relation of values must hold with such farmers as are of the opinion that what the cows eat of the stover will produce as much milk as the same weight of hay eaten. An acre in corn should give of stover three tons, or certainly not less than 2¼ tons of cattle food, with ¾ of a ton for bedding.

Some farmers in our neighborhood are not willing to estimate their stover at more than $6 to the ton. If the cows consume of the ton 1,500 pounds only, he will be paying out more than four-tenths of a cent a pound for the portion eaten by his cows. It is $6 for ¾ of a ton of food and ¼ of a ton of bedding.

This difference in valuation is enormous, and needs to be reconciled before we may truly estimate the value of an acre of corn to the Massachusetts farmer. In our societies' transactions, we find the value of stover to the acre sometimes placed at $45, or $15 a ton, but we do not have the price of hay given for the localities.

On Waushakum Farm we think it probable that a valuation of $8 a ton for the stover is a low estimate; when hay is $20 a ton, we should not be surprised if careful feeding experiments showed the stover to be worth considerably more. In fact, hay is commonly worth in the market nearer $25 than $20 a ton, and often goes higher. If, therefore, the proportion of 8 to 20 is preserved, the stover will probably be worth more than less.

It does not seem surprising that the stover should be esteemed of small value when it is regarded as a waste product, and treated with neglect; but it is somewhat surprising that it should be ever so regarded, when the price of hay is considerable, in view of the high esteem in which corn stover is held by some farmers.—*J. N. S., in Scientific Farmer.*

BARNYARD MANURE.

THE foremost, longest known, most used, most trusted of all manurial substances, is barnyard manure, the dung of animals. What is it? It is the material we feed the animals, reduced to a fine condition by the process of digestion, deprived of a portion of its constituent parts, which have been used in the animal economy for the manufacture of flesh and bone, milk and wool, and less the amount wasted by being dropped where it cannot be saved, and with the addition of substances used for bedding and absorbents. Since it is the direct product of food used, it is evident that the richer in fertilizing elements the food is, then the more valuable will be the manure. The well-known fact in practice, that grain-fed stock produce a better quality of manure than those fed on hay alone, or on poor fodder, corroborates this statement. Average stable manure is held to contain 0·3 to 0·6 per cent. of nitrogen, 0·4 to 0·6½ per cent. of potash, and 0·2 to 0·3 per cent. of phosphoric acid. This is a fair proportion of the essential plant food ingredients, and confirms the statement often made, that barnyard manure is a complete manure. So it is, as all practice shows, and when produced on the farm, is the most economical. But the above figures show that, at 15 cents per pound for nitrogen, 7·5 cents per pound for potash, and 5 cents per pound for phosphoric acid—the price these substances are worth in stable manure in comparison with them in more available forms in commercial manures—the value of a cord of stable manure, weighing 2½ tons, is about $6.50, instead of $8, $10, and $12, usually paid, with $2 to $5 added for cost of transportation.

Suppose we sell no produce from the farm which contains these essential plant-food constituents, viz.: nitrogen, potash and phosphoric acid, then we will have, in manure, made all the fertilizing ingredients removed in the crops to return to the soil, and the land will be continually increasing in fertility. Butter, perhaps, is the only product not containing them, it being made up wholly of carbon, hydrogen, and oxygen, which, as we showed in the previous article, though essential components of plants, are all supplied by natural means. Following is a table giving the amounts of the substances named, in 1,000 pounds of each of the more common products of the farm:

	Nitrogen.	Potash.	Phos. Acid.
Wheat Grain	20·8	5·5	8·2
Rye "	17·6	5·4	8·2
Barley "	15·2	4·8	7·2
Oats "	19·2	4·2	5·5
Indian Corn Grain	16·2	3·3	5·5
Peas	35·8	9·8	5.8
Beans	40·8	12·0	11·6
Potatoes	3·2	5·6	1·8
Beets, common	1·8	4·3	0·8
Turnips	1·8	3·0	1·0
Hay	13·1	17·1	4·1
Live calf	25·0	2·0	13·8
" ox	26·0	1·7	18·6
" sheep	22·4	1·5	12.3
" hog	20·0	1·8	8·8
Wool	94·4	1·9	0·3
Milk	6·4	1·7	1·9
Cheese	45·3	2·5	11·5
Eggs	21·8	1·6	3·2

Therefore, in every 1,000 pounds of produce sold, we prevent the amount of plant-food given in the table from going into the manure heap and back upon the soil. In addition to butter, we may add the fatting of mature animals as a branch of farming which does not remove much fertility from the land; for the mature animal has its bones and muscles already formed, and, in the laying on of fat, only removes from its food the same elements as make the butter, though in different proportions. The well-known fertility of farms long devoted to the exclusive production of butter or fatting of animals, is a good illustration of this fact. In such cases, the extra food purchased, and the effect of the applied manure on the soil in liberating its mineral elements of fertility, more than offset the fertility removed in the occasional produce of other kinds sold. It is evident, then, in ordinary farming, that although barnyard manure is a complete manure, and supplies all the elements of plant food our crops demand, yet it is not sufficient in quantity to supply the demands of continual cropping, and we must have recourse to outside aids.

A great deal has been claimed for the physical effect of animal manures upon the soil. First, of the crude organic

matter, which, with the water, makes up nine-tenths of its substance. On stiff clay lands, it will lighten the soil and render it more porous and open to the influence of light, air, and temperature. On lands nearly devoid of vegetation, and having but little organic matter, it will make the soil more absorptive of moisture, and gives it the desired "body." But the few past years' experience with mineral manures, seems to indicate that perhaps the majority of our fields under cultivation keep up the necessary supply of organic matter, by the decay of roots, if only the essentials of plant food are furnished, the rest being drawn from the atmosphere. In market gardening, or wherever sufficiently large amounts of stable manure are used, it undoubtedly has a valuable effect in raising the temperature of the soil by heating, which property adds some value to it for gardeners.

What has also been claimed as physical effect is, in fact, chemical, and is possessed equally by the same substances in other forms. The "lasting effect" is due simply to the fact that plants require their food in certain forms; which forms the constituents of this manure only acquire after a longer or shorter season of decomposition and other chemical changes. For example, the nitrogen is mostly in the form of albuminoids, while plants require it to be in the form of ammonia and nitrates, which are produced by decomposition and chemical combination in the soil. The potash is only, in part, at once available, the rest becomes so, and diffused through the soil, in course of time, by the joint action of the nitrogenous portion and other chemical agencies. Similarly with the phosphoric acid. We will conclude with an analysis of ordinary stable manure, which may be considered a fair average. The statement is of 1,000 parts, and taken from German results, as we have not had sufficient analyses made in this country to form an average.

	Water.	Organic Matter.	Total Ash.	Nitrogen.	Potash.	Phos. Acid.	Lime.	Magnesia.
Fresh	710	246	44·1	4·5	5·2	2·1	5·7	1·4
Half rotten..	750	192	58·0	5·0	6·3	2·6	7·0	1·8
Much rotted	790	145	65·0	5·8	5·0	3·0	8·8	1·8

—*Scientific Farmer.*

VALUE OF THE DUNG OF A COW.

ACCORDING to Dr. Anderson, the amount of potash, phosphoric acid and ammonia annually voided by a cow, is as below:

103·3 lbs. of ammonia.
88·5 " " potash.
64·0 " " phosphoric acid.

According to the usual valuation, this represents a value of $22.75, based on the availability of these ingredients in this as compared with artificial fertilizers.

COTTON SEED AS MANURE.

IN Georgia, and other sections of the South, cotton seed is quite largely used in the formation of composts. For this it is well fitted, as it contains a large percentage of plant food. Professor Goessman gives an analysis of the hulls, by which it appears that their ash contains 23·72 per cent. of potash, and 7·88 per cent. of phosphoric acid.

Cotton seed usually contains about 4 per cent. of ash, and two analyses of the whole seed give 27·8 and 36·0 per cent. of potash, and 35·4 and 37·2 per cent. of phosphoric acid.

Cotton seed (decorticated) cake contains about 7·00 per cent. of nitrogen, 2 per cent. of potash, and 3 per cent. of phosphoric acid.

Cotton seed (whole seed) cake, on the contrary, contains but from 3½ to 4 per cent. of nitrogen, but about the same percentage of ash ingredients. A ton, then, of the cake would contain from 70 to 140 lbs. of nitrogen, 40 lbs. of potash, and 60 lbs. of phosphoric acid, and at the usual valuation of 5 cents a lb. for the phosphoric acid, 7 cents a lb. for potash, and 21 cents a lb. for the nitrogen, would be worth for plant food from $22 to $40 a ton.

It is thus seen how foolish it is for the cotton grower of the South to sell his cotton seed at $10 or $12 a ton, or less, as he is doing, and then buying back fertilizers of the dealers. We believe in purchasing and using fertilizers, but not till after the home resources of fertility are exhausted.

MANURIAL SUBSTANCES.

A MANURE is any substance which furnishes food directly to plants; or by undergoing certain changes it becomes fitted for plant food; or by its action upon other substances produces plant food. Some say, also, that any substance is a manure which, by its action upon the soil, renders the soil capable, or more capable, of producing plants; but what of this class is not included in the above, would bring the plow, the drain-pipe, and the sunlight into the category of manures, yet, while we feel that they would not be disgraced by the company, it is best to draw the line somewhere—as the host said when asked why he did not invite his brother to his party.

The manure question, then, comes pretty nearly to one of plant food; in the discussion the subject of the improvement of the physical condition of the soil is omitted. Manifestly, the great economical question before the farmer of to-day, and of the future, is how to feed his crops to the best advantage. There is no doubt but that we every year apply to the soil vast amounts of material which we think is proper and sufficient food for the crops, and that we often apply other kinds of food not needed, while other kinds are lacking. Considering the food question as to animals, accurately, there are a few simple substances: fats, albuminoids, starchy compounds, and a few mineral substances, which always form their food. These, too, are found in practically unvarying proportions in the parts of the animal Lean beef is always made of the same substances, in the same proportions so with the flesh of the healthy ox, the horse, the hog, varying only with the kind of animal; so, too, with the bones, the skin the hair, and other parts. No matter how complicated the form of the food eaten may be, the portions which go to build up the structure of the animal are ever the same. With plants the principle is the same, though much simpler.

All who understand the structure of plants are practically agreed that but a few substances are necessary for their food; and, save in a few special cases, the only difference in the composition of different plants is in the proportion in which these substances are brought together. These substances, in their simplest form, are oxygen, hydrogen, nitrogen, carbon; sulphur, phosphorus; silicon, chlorine, potassium, sodium, calcium, magnesium, iron, manganese, with a few others rarely found.

Of these, the oxygen and hydrogen in the form of water, and the carbon united with oxygen in carbonic acid, are furnished in abundant quantities by natural means for the supply of all our crops. Silicon with oxygen makes silica or silex, which is familiar to all as the greater component of common sand; though forming sometimes as high as one-half of the ash of plants, yet is furnished in abundance by nature, composing, as it does, the mass or groundwork of all ordinary soils. Sulphur is found in nearly every organic substance applied to the soil in sulphuric acid forms with lime the commonly used plaster—plaster or sulphate of lime being found in all superphosphates—and being used as sulphuric acid in the manufacture of most fertilizers, is supplied to crops in sufficient quantity, almost without effort on our part. Calcium with oxygen forms lime, and, in this form exists in nearly every manurial compound, and, being a prominent constituent of most soils, seldom needs special attention as plant food. It is, however, a substance of great importance on account of its powerful action upon organic substances, and in connection with the latter upon minerals. Chlorine, sodium, iron, and manganese are either found in abundance in soils generally, or are so common in substances used for manure, that we need not bother ourselves to specially provide them for the plant. Magnesium with oxygen forms magnesia, and in this combination is an essential component of the food of plants, but for most crops is furnished in sufficient quantities by the soil, or in ordinary manures.

Thus we have narrowed down the list of the essential elements of plant food to three, viz.: nitrogen, phosphorus, and potassium; the last two are more familiarly known in their compounds with oxygen, as phosphoric acid and potash. Whether we apply barnyard manure, superphosphate of lime, ashes, potash salts, animal fertilizers of any kind, Peruvian guano, fish guano, or other manure of any sort, if we seek to feed the crop, the valuable portion is one or more of the above-named essential ingredients.—*Scientific Farmer.*

THE TULIP TREE.

By WM. BACON.

THIS tree, *Liriodendron tulipifera*, is peculiar to North America, and is found along the Atlantic coast from Canada to Florida, and as far west as the Mississippi. It is known by different names in different localities, such as whitewood, canoe-wood, and yellow-poplar. Vasey, in his description of the timber from American trees, exhibited at the Centennial Exposition, classes it with the magnolia family, where it properly belongs.

The tulip tree is rarely found in the Atlantic States near the ocean, but in Massachusetts it is not uncommon along the Connecticut river and in many localities in the western part of the State. It attains its largest size in the Western States, where it is said to reach heights of from 120 to 140 feet, and instances are given where the trunks of trees four and five feet from the ground, measured from 20 to 22 feet in circumference. It is said to preserve its size with great regularity in its native forests, and to be free from branches and knots to a great height; but in the park or the avenue, for which it is admirably adapted, it should have room to encourage the growth of lower branches.

A striking peculiarity of the tulip tree is in the form of its leaf, which often measures six inches at its greatest width, and at that point it is truncated, or has the appearance of notches cut in it and pieces taken out, and from this truncation the leaf is only about half of the width of the base. The blossom of the tree, which is very showy and very abundant in June or July, according to locality, in form and color resembles a gayly painted tulip, and in the verdant days of summer, gives a cheerful contrast to the wide-spreading foliage of the tree. The blossoms, which remain several days, are followed by a cone-like appendage, which consists of thin, narrow scales, attached to a common axis, the whole being three or four inches long. These cones often remain upon the tree from one to two months after the leaves are fallen, or indeed, until they are broken up and their scales scattered by the winds of winter. On a tree of our own planting, which has shown fresh flowers to gladden our eyes for many years, we estimated that there were three hundred of these cones remaining after the first snowfall in December last, and from the seed of these three hundred cones, now scattered by the winds, we expect many young tulip trees will spring up in the hedges and waste places round about, to the pleasure, we hope, of those who will appreciate them.

The tulip tree is easily raised from seeds sown in soft mold, and if sown in autumn will come up the next spring. If transplanted, it should be done while the tree is very young, as it has a heavy tap-root, with few fibers. Hence, care must be used in taking up, and the more of the main or descending root that is obtained, the greater will be the amount of fibers or feeders. Where a half dozen trees are planted for ornament or shade, the tulip tree should be one of the selection.—*Country Gentleman.*

[COUNTRY GENTLEMAN.]

HORTICULTURAL NOTES.

New Grapes.—While so many enterprising and patriotic cultivators are engaged in raising new varieties of the grape, it must not be inferred that we have not still a vast field before us to improve. A perfect grape has not probably been yet reached. We have the Concord, Hartford, and Clinton, for hardiness; we have Creveling, Delaware, Walter, and Rebecca, for excellent quality—all natives. Now, what we want is to place the Rebecca and Delaware, with their excellent qualities (but with feeble vines) on such strong, hardy vines as those of the Concord and Hartford. We want to put the flavor of the Delaware into such a large grape as Union Village. We would like to give to the Creveling the compact bunch of the Diana. We would like to put the sweet and rich Walter on the iron-clad vine of the Clinton. We could go on without limit, and enumerate suggested improvements which might be effected by crossing, without entering the uncertain field of the exotic varieties. There is no reason why the above suggested combinations should not be made, with the additional one of extreme earliness, so that the grape grower may have yet upon his table a daily supply of delicious bunches, from early August to early April. An immense field for crossing is open before us.

Hasty Conclusions to be Avoided.—Prof. Swallow stated in his address at Missouri University that sixteen years ago he planted fifty pear trees in cultivated ground, and thirty in blue-grass sod. An average of ten per cent. of those cultivated died in each year, but none of those in grass. This difference continued to some extent for fifteen years, and it was proposed to publish the result, and announce the grass sod as a perfect preventive. In the sixteenth year the blight came on the trees in grass, and spoiled the theory. There is no doubt, however, that the great natural fertility of the soil in Missouri gave the cultivated trees too rank a growth, and that the retarding influence of the grass was useful. We had an orchard of several hundred standard pear trees, a part in grass, a part cultivated, and a part manured and cultivated. For fifteen years all were free from blight; not a vestige appeared on one. But the sixteenth year the blight came on all alike, and wagon loads of the dead limbs were drawn off. We shall have to wait and observe a little longer before laying down inflexible conclusions and rules.

Garden Use of Fertilizers.—Peter Henderson urges the importance of pulverizing finely and mixing thoroughly with absorbents, all concentrated manures, such as guano, in order to obtain the best effects. He recommends adding to every bushel of the fertilizer three bushels of leaf mould, pulverized muck, etc., or in their absence common garden soil—the material to be as dry as it can be made. [Road dust would be still better, as it is already dry and finely pulverized.] Mr. H. would turn and mix all the ingredients at least twice before using. He states that a successful market gardener finds that 1,200 lbs. of guano mixed with two tons of garden soil, and sown over the ground after plowing, and then harrowed in, are fully equal to 2,000 lbs. of guano used without mixing. He finds in practice that guano at $80 per ton, blood fertilizer at $65, bone dust at $50, and superphosphate at $40, are about equally profitable to use. On other soils the relative values might vary greatly.

Lime Dust.—The following has been recommended as the best mode for preparing lime dust for slugs and other insects, for mildew, etc.: Take say a peck of fresh or sharp lime, broken up into small pieces; then add four pounds of flour of sulphur, or in like proportions if in smaller quantity. Add one-third as much boiling water, or just enough to slack the lime to dry powder, and cover the vessel as soon as the water is poured on. By adding water, it may be made into an excellent whitewash for trees, the sulphur increasing its efficacy.

Low-Headed Trees.—D. S. Marvin gives in substance the following reasons, in the Watertown *Post*, why all fruit trees should be trained as pyramids or with limbs branching from the base of the stem without any bare trunk: 1. The stem is protected from injury from the hot sun and sharp winds. 2. It is easier to gather the crop. 3. The fruit is not so much bruised in falling. 4. The trees are more readily kept in handsome symmetrical form, being within reach of the pruning knife. 5. They are more accessible in destroying caterpillars and other insects. 6. They are less liable to injury by the borer. Every cultivator must decide whether these advantages overbalance those of trunks trimmed high to permit the cultivation of the soil nearer the tree, and for the growth of crops between the rows.

Liquid Grafting Wax.—A correspondent of the *Practical Farmer* gives the following directions for making liquid grafting wax, which, being about the consistence of honey, may be readily applied with a brush for outdoor grafting, without the trouble of heating. It is also excellent to cover cuts made in pruning. Melt together 1 lb. of rosin and 1 lb. of good beef tallow. Remove from stove and let cool until a scum forms over it, then add 1 teaspoonful of spirits of turpentine; replace on stove and add 7 oz. of a mixture of 2 parts strong alcohol and 1 part water, stirring briskly, and taking care that the alcohol does not inflame, as it will if the mixture is too hot. Stir until the liquid is lost in the mixture, when it should be of the consistency of honey. Keep in a closed bottle and apply with a brush. If after a month or two it becomes hard, remelt, add a few drops more of the turpentine, and more of the alcohol and water. A few days after it is applied it becomes hard, and will remain unchanged, except that it grows harder, for an indefinite time.

[NATURE.]

NOTES.

The Woodpecker.—At the session of the German Ornithological Society, on February 8, Professor Altum gave an interesting address on the ordinary woodpecker, embodying a portion of the results of over seven years' observation. With regard to the question of how the woodpecker finds the trees inhabited by insects, he had noticed that it almost invariably resorted to such trees as bore the diseased look consequent upon the presence of insects, manifested by the smallness and fewness of the leaves, the absence of the usual fresh color of the bark, etc. In some cases it is deceived, especially where new varieties of trees have been set out. When it has detected a hole bored in the bark by insects, it follows the course of the passage under the bark by a gentle tapping with its bill, until it reaches the place where the larvæ are situated, when, by tearing off large portions of bark, its food is laid bare. Among the insects not eaten by the woodpecker are such as the *Cerombyx heros*, which bores too deep into the wood, or small insects such as the *Bostichidæ*, living in the bark of the pine tree, which is difficult to penetrate. The presence of the woodpecker is good for a forest, in so far as it destroys the insects upon the trees. It, however, injures the latter frequently by tearing off large pieces of bark, and indirectly by eating the useful wood ants. The statement that woodpeckers made incisions in trees free from insects, for the purpose of sucking the sap, was disproved by Professor Altum, on ground of repeated observations.

Sagacity of a Lobster.—A few days ago at the Rothesay Aquarium, a tank containing flat fishes was emptied, and a flounder of eight inches in length was inadvertently left buried in the shingle, where it died. On refilling the tank it was tenanted by three lobsters (*Homarus marinus*), one of which is an aged veteran of unusual size, bearing an honorable array of barnacles; and he soon brought to light the hidden flounder, with which he retired to a corner. In a short time it was noticed that the flounder was *non est*. It was impossible the lobster could have eaten it all in the interim, and the handle of a net revealed the fact that, upon the approach of the two smaller lobsters the larger one had buried the flounder beneath a heap of shingle, on which he now mounted guard. Five times within two hours was the fish unearthed, and as often did the lobster shovel the gravel over it with his huge claws, each time ascending the pile and turning his bold defensive front to his companions.

Nerve and Muscle Currents.—M. Steiner has proved (*Reichert's Archiv*) that the electromotive force of the nerve-cur-

rent from 2° upward, is greater the higher the temperature, that it reaches a maximum between 14° and 25°, and at higher temperatures decreases again. The force of the muscle-current is likewise, from 5° upward, greater the higher the temperature; it has its maximum between 35° and 40°, and at higher temperatures becomes less again, till, when rigidity sets in, it is almost *nil*. Thus, for the nerve and muscle current, as well as for other functions of living organic forms, there is a *temperature optimum;* which is as distinctly marked when, by heating, we rise to it from lower temperatures, as when we descend to it by cooling from higher temperatures.

Siberian Explorations.—The St. Petersburg papers announce the return of Lieut. Onatsevitch, who has spent two years in the survey of the Northern Pacific shores of Siberia. After having observed the transit of Venus, Lieut. Onatsevitch engaged in a full and thorough survey of Behring's Strait, extending his soundings into the glacial ocean as far as the ice barrier over a surface of about sixteen square degrees. Further, having at his disposal fourteen chronometers, he has determined many longitudes, and has brought into connection the longitudes formerly determined in the northeast with those recently determined with great accuracy before the transit of Venus in southeastern Siberia. The work done by M. Onatsevitch will be the subject of communications at the next meeting of the St. Petersburg Geographical Society.

Volcanic Lakes.—At the meeting of the French Geographical Society, M. Charles Velain read a paper on the volcanic lakes of the island of Nossi Bé, near Madagascar. The formation of the island is generally volcanic, the north and south parts being of ancient formation, while the central part is of much more recent origin. Besides a number of true volcanic craters, not very high, M. Velain found a great number of crater lakes or circular troughs, level with the ground and filled with water. These troughs, M. Velain thinks, must have been formed by subterranean explosions, which did not last long enough to enable the lava to reach the surface. These lakes abound in fish, many of which are probably new species; it is impossible, however, to catch them, on account of the number of crocodiles that swarm on the banks.

Telluride of Gold.—In the February session of the Hungarian Geological Society, Professor Krenner displayed a lately discovered mineral from Nagyág, which consisted of pure telluride of gold. As is well known, gold does not occur in nature in combination with any member of the sulphur group except tellurium. A mixture of the tellurides of silver and gold was found recently in California, but this is the first instance of the occurrence of the pure auric telluride in a crystalline state. In view of the fact that gold is the noblest metal, and tellurium one of the rarest elements, the new mineral has been called *Bunsenite*, in order to give a fitting expression of the gratitude of the great chemist's admirers in Hungary for the services rendered to mineralogy by his analytical methods.

Rapid Growth of Coral.—A remarkable piece of coral, taken off the submarine cable near Port Darwin, is spoken of in a Melbourne paper. It is of the ordinary species, about five inches in height, six inches in diameter at the top, and about two inches at the base. It is perfectly formed, and the base bears the distinct impression of the cable and a few fibers of the coil rope used as a sheath for the telegraphic wire still adhering to it. As the cable has been laid only four years, it is evident that this specimen must have grown to its present height in that time, which seems to prove that the growth of coral is much more rapid than has been supposed.

Pneumatic Clocks.—On February 25th the city authorities of Vienna inaugurated a novel and remarkably interesting application of pneumatic tubes for the purpose of maintaining unison and regularity in widely separated time-pieces. The inventor is the Austrian engineer and electrician, E. A. Mayrhofer, who, after vainly trying to solve the problem by means of electricity, finally hit upon the new system. From a central bureau in the city, connected with the Imperial Observatory, these pneumatic tubes extend in all directions, laid alongside the gas mains, and branching off to the public clocks. By means of a simple apparatus in the latter the authorities in this bureau are able to exhibit the true astronomical time on the clock dials in all parts of the city, a movement of the hands occurring once a minute. At present only the city clocks have been brought in connection with the new system, but it will rapidly be extended, until it embraces the time-pieces in all the schools, public institutions, hotels, etc., and in private residences where it may be desired.

The Light of the Rainbow.—Taking opportunity, lately, to observe with a Nicol's prism an uncommonly fine rainbow, which spanned the Oesthal in Baden Baden, M. Schiel found that with the prism in a certain position, the colors disappeared completely, and the prism was pretty dark. But on turning it through 90°, the bow appeared again in all its brilliancy. The rainbow is therefore perfectly polarized light. Several rainbows observed since have shown the same behavior; but apparently only a very bright colored rainbow presents dark on the field of vision with the corresponding position of the prism.

The occurrence of gold disseminated in small quantities through the older geological formations of Australia has been known for many years. But Mr. C. S. Wilkinson, of the Geological Survey of New South Wales, has observed what seems to be a new fact, that gold in sufficient quantity to be worth mining, occurs in a conglomerate belonging to the coal measures, and that the alluvial gold of the Old Tallawang diggings has been derived from the waste of these conglomerates. He justly points out that, apart from the scientific interest belonging to so venerable an auriferous alluvium, considerable commercial importance attaches to its discovery, seeing that the conglomerates may now become a new source of supply for the precious metal. At Clough's Gully the actual conglomerate is now being worked, and yields from 1 dwt. to 15 dwts. of gold per ton, and nuggets sometimes weighing 5 ounces.

A memorial to Lomonosoff, erected in the square of the University of Moscow, was unvailed on the anniversary day of the university, January 24. The memorial, which was erected at the very moderate cost of £225, collected among professors and students of the Moscow University (founded by Lomonosoff in 1755), is very modest. It consists of a small bust placed on a high very plain pyramidal pedestal bearing the inscription: "To Lomonosoff—the Moscow University: year 1877." In an address by M. Solovieff, Professor of History, he briefly sketched the impulse given to science in Russia by Lomonosoff, and insisted especially on the importance of his works in the development of the history of his nation. No reference was made to the task performed by Russia's first physicist. We are glad to take this opportunity to say that it is a great pity that the Russian learned societies have not yet published a collection of the works of Lomonosoff, all the more, as many of his writings dispersed in rare old periodicals, are now totally unknown or forgotten. This neglect induces us to think that Russian men of science have not yet fully appreciated the depth and width of the physical conceptions of this remarkable physicist of the past century, who not only devoted his time to the study of the most important questions of astronomy, physics, and physical geography (as, for instance, the transit of Venus, the existence of ascending warm currents in the atmosphere), but also in a now forgotten, but able paper on the Arctic Seas, expressed himself very explicitly as to heat being but a mode of motion. We think, therefore, that a complete edition of Lomonosoff's works would be not only an addition to the glory of the science of the eighteenth century, but also a most interesting acquisition for all those who are interested in the history of science.

Dr. Petermann has just published an index to his *Mittheilungen* for the period between 1855–1874. This will be of great value to geographers, and its value is much enhanced by two most ingeniously constructed index maps which show the various parts of the earth that have been mapped in the *Mittheilungen* during that period, and in a simple way indicate where the map will be found. Besides a general index map there are maps of the various continents and of the arctic and antarctic regions. By differently colored lines the scale of the special map referred to is shown, as also its character, whether outline, topographical, physical, or geological.

A party of the Swiss Alpine Club have availed themselves of the prevailing mild weather to extend their yearly winter excursion in the mountains as far as the Col de Balme. They crossed the mountain pass on January 21, and, after many pleasant adventures, reached the hotels of the Col, which were so deeply buried in snow that the way to the rooms had to be made through the windows of the first floor. Other parties, of French and Swiss excursionists, visited about the same time the renowned archæological ground lying in the Jura between Montbelliard and Porrentruy. The special aim of the excursions was to organize a scheme for a thorough exploration and a detailed survey of these localities to be undertaken next summer. If we take into account the immense number of caves, rocky *abris* (shelters), tumuli, grave walls, open dwelling places, and megalithic stones scattered over this part of the Jura, and the strange anomalies observed in the geographical distribution of these remains of prehistoric man (only caverns and rocky *abris* being known in the Swiss part of the Jura, whilst the French part abounds with all kinds of remains enumerated above), we cannot but hope that an exploration of these localities will result in valuable contributions to prehistoric archæology.

A new form of marine sounder has been described to the French Academy by M. Tardieu. It consists of a spherical envelope of caoutchouc, a few centimeters in thickness, communicating with an iron reservoir by means of a tube of small diameter fitted with a valve. The caoutchouc envelope being filled with mercury, any increase of the exterior pressure makes a certain quantity of mercury pass into the iron reservoir, whence, however, it cannot return. When the apparatus has been lowered in deep water, the weight of the mercury found in the reservoir enables one to determine the pressure to which it has been subjected, and therefore the depth.

Mock Suns.—The Denver *News* states that after a severe snowstorm on the night of December 22, 1876, the sun, next morning, rose clear, but the air was filled with particles of frost, the refraction from which caused the appearance of "mock suns" or "sun dogs." First, extending from the sun right and left was a circle entirely around the heavens. Along it were the "sun dogs" in their usual places, with extra ones in the northwest, southeast, and southwest, being directly opposite the sun and at right angles to that line. A very bright circle, like a continuous rainbow, surrounded the sun, at an angle twenty or thirty degrees from it, and crossing the horizontal circle at the most brilliant of the false suns. Another and similar circle, and of about the same diameter, occupied the zenith. Thus there was a complete circle around the horizon, and twenty to thirty-five degrees above it two complete rainbow circles of exceeding brightness and seven "mock suns" or "sun dogs." The spectacle lasted, with changing effects, for two hours or more.

A series of measurements of the calorific intensity of solar radiations and of their absorption by the terrestrial atmosphere, has been lately made by M. Crova. His mode of observation is described in the December number of the *Journal de Physique*. He has ascertained that the law of transmission of radiations may be represented by an expression of the form $y = \frac{Q}{(1+ax)}\, b$, in which y represents the calorific intensity of radiations which have traversed an atmospheric thickness equal to x; Q is the solar constant which, in the author's experiments, is represented by values generally superior to two units of heat received per minute on a square centimeter; a and b are two numerical constants determined by the position of tangents to the curve drawn at different points. The co-efficient of transmissibility of the radiations through an atmospheric thickness equal to unity varied, in the circumstances in which M. Crova measured it, between about 0·940 and 0·800, according as the atmospheric thickness already traversed was more or less considerable.

Apatite and Nephelin.—Mineralogists have often been troubled to distinguish with certainty between apatite and nephelin. A. Streng communicates in the last *Mineralogischen Mittheilungen*, a simple but secure method for overcoming this difficulty. If a drop of a concentrated solution of ammonium molybdate in nitric acid be placed on a thin section of an apatite crystal under a microscope, the observer notices quickly the formation of a circle of small yellow crystals of $10M_2O_3 + PO_4(NH_4)_3$, either in the form of regular octahedrons, or of regular rhombic dodecahedrons. A second test is the following: If a drop of sulphuric acid be added to a section which is already partially dissolved in nitric acid, the formation of crystals of gypsum is easily noticed. Nephelin yields negative results in both cases; a positive test for its presence consists in the addition of a drop of hydrochloric acid to a thin section under the microscope. After the lapse of a few minutes the formation of numerous small colorless cubes of sodium chloride is quite perceptible. They result from the decomposition of the silicate of sodium by hydrochloric acid, and the insolubility in the latter of the salt thereby formed.

Formation of the Diamond.—We have received from a correspondent a very detailed account (illustrated by drawings) of the Kimberley diamond mine in South Africa. The conclusion as to the mode of origin of the diamonds to which his study of the district appears to have led our correspondent is as follows: That they were formed in volcanic vents which have been opened in the midst of sedimentary rocks (sandstone and shale, with thin coaly seams), which vents probably existed at a considerable depth under the sea. As to the material which by its decomposition may have yielded the pure carbon in a condition ready for crystallization, our correspondent suggests that it was probably some hydrocarbon derived from the coal by distillation.

Ants.—Mr McCook has recently brought before the Academy of Natural Sciences, of Philadelphia, an account of his investigations on *Formica rufa*. He finds that ants descending the tree-plants, with abdomens swollen with honeydew, are arrested at the foot of the trees by workers from the ant-hill. The descending ant places its mouth in contact with that of the food-seeker, the two being reared on hind legs. Frequently two or three of its fellows are thus fed in succession by one ant, mostly complacently, but sometimes only on compulsion. Mr. McCook made many experiments, which lead to the conclusion that there is complete amity between the ants of a large field, embracing some 1,600 hills, and many millions of creatures. Insects from hills widely separated always fraternized completely. A number of ants from various hills were placed in an artificial nest, and harmoniously built galleries and jointly cared for the cocoons.

Vowel Clang.—From researches on the nature of the vowel "clang," in Prof. Helmholtz's physical laboratory, M. Auerbach (*Pogg. Ann.*) comes to the following conclusions, which appear to throw new light on some unsolved problems: 1. All clangs, especially the vowels of the human voice and speech, are to be defined as the consequence of the joint action of two moments, a relative and an absolute. 2. The relative moment is the mode of distribution of the whole intensity among the individual partial tones as determined by their ordinal number. The absolute is the dependence of the intensity on the absolute pitch of the partial tones, and the modification of the distribution on change of the fundamental tone, therewith connected. 3. The difference of vowels in the former relation is a result of the power of changing the form of the mouth cavity. The differences of the absolute pitches characterizing the various vowels, and of their influence, are a result of the power of changing the volume and size of the mouth cavity. 4. The first partial tone is always the strongest in clang; it deserves, therefore, the name of fundamental tone. 5. The intensity of the partial tones as such decreases in general as their ordinal number increases; exceptions indicate the nearness of the boundary of the consonant region. 6. The intensity of the partial tones decreases more slowly the nearer the vowel clang is, therefore more quickly the duller this is. 7. The characteristic pitch is higher the clearer, and deeper the duller, the vowel clang. 8. The variations of the intensity, in consequence of the influence of the characteristic pitch, are greater the fuller the vowel is. Very slight variations indicate the nearness of the consonant region. 9. All the vowels admit of being sung within the whole range of the human voice; but the dull speak in very high, the clear in very deep, positions. 10. A little attention only is needed to perceive in a vowel clang the over-tones (often comparatively very strong) without artificial aids. They then sound very similar to the pure tuning-fork tones.

Fluorescence.—M. Lommes (*Pogg. Ann.*) arrives at the following conclusions: 1. There are two kinds of fluorescence. In one each excitant homogeneous ray falling within the limits of the fluorescence spectrum excites not only rays of greater and equal, but also rays of shorter, wave length; the latter so far as they belong to the region in question. In the second kind, each homogeneous ray excites only rays of greater or equal wave length. 2. There are substances which have only the first kind of fluorescence; each excitant ray excites the whole fluorescence spectrum. Hence they are not subject to Stoke's law. Such are naphthalin, red chlorophyll, and eosin. 3. There are substances which have only the second kind of fluorescence, and which, therefore, throughout their fluorescence spectrum, obey Stoke's law. Such are most of the fluorescent substances hitherto examined. 4. There are substances which have both kinds of fluorescence, so that the first kind is proper to a certain portion of their fluorescence spectrum, and the second kind proper to their remaining parts. Hence, these obey Stoke's law only in part. Such are chamaelin red, blue, and green.

Decomposing water with only one electrode. One way is this: Let some water in a glass be brought in contact with a Wollaston electrode (*i.e.*, a fine platinum wire inclosed in glass and touching the water only by its extreme section), and connect the wire with the conductor of an electric machine in action. Fine bubbles of oxygen are liberated at the point. What becomes of the hydrogen? M. Lippmann replies (*Journal de Physique*) that so long as the water continues charged the hydrogen remains in excess. On discharging the water it escapes at the platinum point, this, being then, the electrode of exit. But may it not be that the hydrogen is set at liberty within the liquid or at its surface while the corresponding oxygen is liberated (there being, according to this view, two electrodes; one the platinum point, the other diffuse and of large surface)? The objection, M. Lippmann says, cannot be refuted by direct experiment, but the impossibility of the hypothesis appears on considering the quantities of chemical and electrical work called forth during the experiment. He gives two demonstrations of this.

SAFE CATERPILLARS.—A pleasant story is told by Sir John Lubbock, quoting from Weissmann, illustrative of the means of protection which some insects possess. The caterpillar of the sphinx moth is quite as good food for birds as any other insect; but it is perfectly protected by its ugliness. Its face is its fortune, having two great spots on it which look like eyes when the caterpillar wriggles. In general the insect is suggestive of a small snake, especially when it is frightened so that it draws back its head and shows its false eyes to advantage. M. Weissmann put one of these caterpillars into a seed tray where he usually fed sparrows and other small birds. The first bird that alighted on the edge of the tray, perceiving the insect, became half paralyzed with fear. Eight or ten birds joined the first one, but all stood on the edge of the tray, afraid to go in. One bird flew into the tray at first, but on seeing the caterpiller hastily scrambled out and joined the company on the edge that were bobbing their heads up and down, and looking into the tray as if half terrified. After the caterpillar was removed the birds went into the tray for seeds as usual.

ORNAMENTAL WROUGHT-IRON GATE.—DESIGNED BY A. NARTEN. MADE BY W. HEUGST, HANOVER.—(*From the Workshop.*)

PHOTOGRAPHY IN LACE FACTORIES.

IN South Germany, the assistance of photography is aptly made use of in lace factories in the production of *dentelles a l'aiguille*, and at a lecture recently delivered at Vienna by Dr. Martin, the former President of the Vienna Photographic Society, that gentleman gave an interesting demonstration of the art in this connection.

It appears that in this particular description of lace there is considerable difficulty experienced in securing the fabric uniform, some of the work-girls making it too fine and others too course. It is made in pieces, which are subsequently fitted together, for it would be practically impossible to wait until one hand had made a piece of sufficient size. A large number of girls are therefore employed on separate parts, which go to make up a perfect piece, and which therefore must all of them resemble each other as nearly as possible.

The ordinary method is to supply the work-girls with outline sketches or designs upon straw paper, in which the ground, so far as its dimensions are concerned, is but roughly marked with colored strokes. Under these circumstances it often happens that the work of the girls vary considerably in regard to the size of the holes and the breadth of the margins, so that there is a want of harmony in a parcel of the lace—a circumstance giving rise to the necessity of carefully sorting out pieces to fit one another, so that no awkward joins may be apparent.

To avoid any such difficulties, it is now the custom to pick out the cleverest work-girl and let her commence upon a design given her upon straw paper. She finishes a piece in accordance with this design, and this well-executed piece of work is then stretched in front of a black background and photographed. The cliché obtained, a Lichtdruck block is produced, and from this a large number of copies are struck off. Each work girl receives a copy of the photograph, so that not only has she in her possession an outlined design, but the equivalent of a piece of finished lace, which she has merely to imitate, in order that a uniform parcel of work may be secured. A very large number of girls may be employed upon one design in this way, without the manufacturer being under the least apprehension that the many results will vary in character.

In this application photography appears not merely as a multiplying medium in the matter of design, but as fulfilling an integral part in lace manufacture.—*Photo. News.*

PHOTOGRAPHIC REPRODUCTION OF BANK NOTES.

PHOTOGRAPHERS are certainly very clever people. The most recent feat that they seem to have successfully accomplished is the reproduction of the blue notes of the Bank of France and the red ones of some of the Scotch banks. Both red and blue have for a long time past been deemed sufficient to baffle such professors of the black art as strive to compete with Government and bankers in the production of these valuable documents. The National Bank at Vienna has, however, it appears, lately been much troubled with forgeries of the familiar cobalt-blue notes of the French, while from Scotland we hear of genuine and imitation notes being pinned together, so like one another as to deceive all but the most experienced. The colors are not, of course, reproduced by the camera as they appear to the eye, for the supposed safety in the employment of blue and red upon bank notes was that the former comes out very light in a photograph, and the latter very dark. Science has, however, recently shown that the effect of color upon a sensitive plate may be increased and diminished at will. A German chemist has plainly demonstrated that by tinting the collodion used in taking a picture, or by employing glass plates of different colors, objects may be vividly photographed which, under ordinary circumstances, would be only faintly depicted. At the Bank of France, strange to say, whose notes have been so freely copied, there is a photographic establishment where a good deal of useful work is done in the way of discovering forgeries, the sharp eye of the camera being a most searching detective. The slightest erasure upon the surface of a check, or the alteration of a figure which is imperceptible to the eye, is at once made apparent by photography. Color, it would seem, is after all but very little protection, for the English bank note is nowadays very rarely imitated, and the same may be said of the German paper money, which is printed in black and white. A combination of colors, laid one over another, has been suggested, and would probably render the difficulty of copying by means of the camera almost insuperable; but it certainly behoves us, in these days of experiment and discovery, to be very careful in our estimate of the impossible.—*London Daily News.*

SUBSTITUTE FOR GLASS IN DRY PLATES.

COL. WORTLEY'S instructions for producing negative tissues are brief and practical:

"Paper is coated with a solution of india rubber in chloroform, and, when dry, with a twenty-grain solution of Nelson's opaque gelatin. When the latter is dry, the paper is ironed perfectly flat, and the edges turned up to form a tray. It is then coated with washed emulsion and dried.

"After exposure it is developed, either by use of a dish with a false bottom, as suggested by Mr. Warnerke, or by the simpler method of forming it into a tray by turning up the edges.

"After development, the negative (having been thoroughly washed) is laid, collodion side downwards, on a piece of papier minéral, coated with gelatin rendered insoluble with chrome alum, and gently squeegeed in contact with it. It is then floated, back downwards, on warm water, to loosen the negative from the first paper by dissolving the gelatin; and you then have a collodion film attached to the papier minéral, and ready for printing.

"This way of working gave me two advantages. I was able to use a thick paper—in some experiments even cardboard—as the original support of the film, while the finished negative was on papier mineral, ready for printing and in the best state for any necessary retouching. I may mention that, if preferred, the negative may be allowed to dry, and be transferred at any time subsequently to its development; and that, if it is desired to reverse the negative, it can be floated off the original support, and then taken on to the papier minéral, so as to have either side that may be desired next to that paper.

"The above process I have found of great value in the reduction of my impediments in traveling."

WEAKENING OPAQUE NEGATIVES

By E. RIEWEL.

MOST photographers have known instances in which their negatives have been too vigorously intensified, a defect which not unfrequently occurs in the case of reproductions. Under these circumstances, I proceed as follows:

I do not, as is the usual custom, moisten the plate with water, but pour over the thoroughly dried negative a strong solution of cyanide of potassium. This must be done at one sweep, as in the developing an image, otherwise spots will surely be seen.

After permitting the solution to act upon the image for some time, I let the liquid run off, and when necessary pour over fresh cyanide solution, and finally rinse thoroughly with water. Should the image after this treatment remain still too opaque and dense, the experiment must be undertaken a second time, only care must be taken to allow the film to dry before proceeding.

The action of a solution upon a dried film in this way seems to be more energetic than where the silver image is first of all impregnated with water.

As the film may betray a tendency to leave the glass plate, especially if the process is repeated more than once, it is well, before beginning the experiment, to coat the margins of the plate with varnish, so that the liquid may not loosen the edges. I may call attention to the circumstance that the tone of a plate treated in this way is altered in a very palpable manner; it assumes a yellowish tinge, which, as every practical man knows, yields far better prints than plates possessing a bluish tone.—*London Photo. News.*

PHOTO HINTS.

Caution in Washing Prints.—If silver prints are washed in very cold water in a warm room, numerous little air-bubbles affix themselves to the print. These remain often very obstinately upon the photographs, and stand in the way of the picture being freed from the hyposulphite of soda. It is advantageous, therefore, to wash prints in boiled water that has cooled, or to keep the prints so much in motion that the air-bubbles are destroyed.

Stoppers for Varnish Bottles.—Varnish bottles are best closed with stoppers formed of good and pure wax, or corks may be used which have previously been dipped in molten wax. If corks are employed with no wax coating, they very often stick fast in the bottles, and particles are often removed which render the varnish impure.

The Production of Special Bust Pictures.—The vignette masks have nearly all of them a pear-shaped outline, and in printing, the broad part of the opening is laid upon the breast of the portrait. In this way the picture is printed. A more beautiful effect is secured, however, when the vignette mask, after the print is about three-quarters finished, is turned round, and the broad part of the opening is put uppermost. In the case of ladies with very large head-dresses this method of printing has especial advantages.

Retouching Powder.—This powder is prepared by mixing together—

Dextrine..... ..... 2 parts.
Resin, very finely powdered..... ..1 part.

It may be employed both for application to negatives and to albumenized prints. A leather stump is the best means of application.

Net-like Cracking of the Film.—In employing a collodion prepared with alcohol of too weak a nature, the film is apt to tear, as soon as it becomes dry, in a net-like form. If these cracks occur only in places, the collodion may readily be freed from the defect. It is only necessary to add to it an equal quantity of another collodion, in the preparation of which absolute alcohol has been employed. Another way, also, of helping one's self is by collodionizing the plate more quickly, and not permitting it to dry so perfectly. In the case of strongly iodized collodion, another error may, however, arise, which is known by the name of iodine streaks or flames. But this fault, unless it is very rampant, is only to be seen on the top of the image. In this case the plate should be turned round on the dipper before being put into the dark slide, and redipped, the plate being raised and lowered half a dozen times.—*Photographisches Archiv.*

AT MOUNT WASHINGTON the weather last December was the worst that has been experienced in the seven winters during which the summit has been occupied by a Signal Service station. The four gales of that month occurred almost exactly at intervals of a week apart, and were of unprecedented violence. On December 16th the wind had a velocity of 180 miles per hour. Ice wrenched from the neighboring rocks was blown against the buildings in a tremendous bombardment for several hours. The thermometer fell to 47° below zero—a cold that is only comparable with that encountered on a few of the arctic expeditions. The mean temperature for the month was more than 6° below zero, and the highest point reached by the thermometer was only 22°. English newspapers, commenting upon Capt. Howgate's plan for founding a colony in the arctic regions, have generally suggested that the chief difficulty in the way will be to find men who are willing to endure the hardship and cold of residence in the polar zone. But a season's training on Mount Washington may, it seems probable, determine at once that question, so far as some of the Signal Service people are concerned.

WHY CITIES ARE WARM.—It is a matter of very common observation that large cities are in general warmer than the country around them. This effect is in great measure caused by the interruption of the sweep of the winds; yet as trees interfere with wind quite as effectually as buildings, the interior of a forest should be as much warmed by this cause as is the heart of a great city. But the heat given out by the fuel burned in a city, and by its inhabitants (including the lower animals), is by no means to be disregarded in such estimates. President Eaton of the London Meteorological Society calculates that the consumption of coal in London—5,000,000 tons per year within a surface of 118 square miles—would raise the temperature of a stratum of air 100 feet thick over that whole area 2¼° Fah. every hour. A decided rise in the average temperatnre at Greenwich Observatory has been recorded in a series of years, and is believed to be due to the increase of buildings and population in the vicinity. It has frequently been asserted, and is a matter of popular belief, that settlement and a growth of population have modified the climate of many localities in the United States; but trustworthy statistics on this point are not yet attainable.